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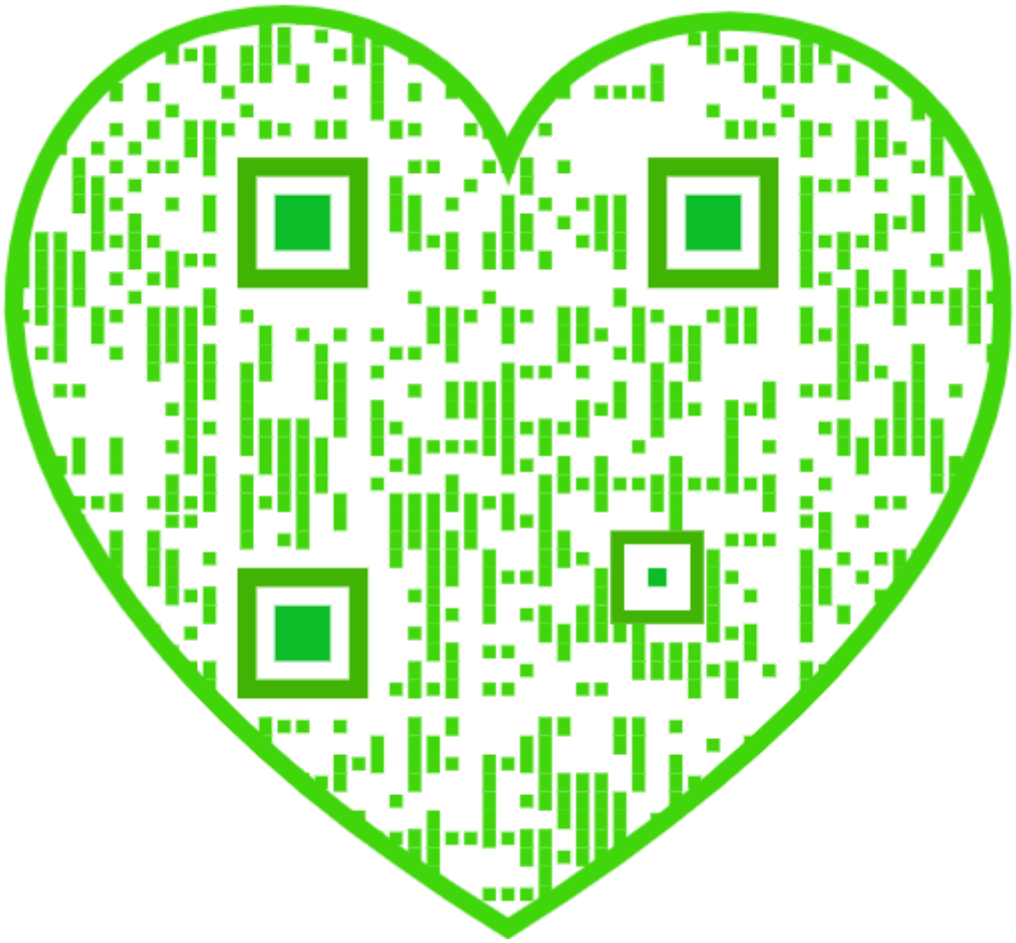

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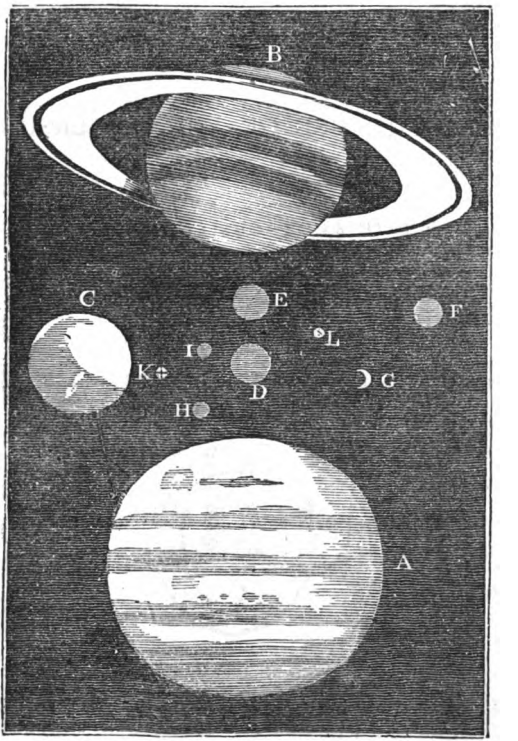

RELATIVE SIZES OF THE PLANETS. (*See p.* 61.)

ASTRONOMY

MADE EASY;

INTENDED

FOR THE USE OF YOUNG PERSONS.

WITH NUMEROUS ENGRAVINGS.

BY W. PINNOCK,

Author of "Pinnock's Catechisms;" "Grammar of the English Language;" "Grammar of Modern Geography and History," &c.

TWELFTH EDITION.

LONDON:

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MDCCCXLVII.

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TO THE PRESENT EDITION.

THE very extensive and rapid sale which the Author's *New Series of Preparatory School Books* has enjoyed, since the first appearance of several of the little volumes that are comprised in it, sufficiently proves them to have become adopted in most of the Scholastic Establishments in the United Kingdom. The Author, therefore, begs to offer his grateful acknowledgments for this very favourable reception, and to express his determination of proceeding with the Series, and of rendering it worthy of the patronage already bestowed on it, and fully adequate to the purpose of its publication, which was, "its adaptation to the teaching of *one hundred pupils* as easily as *one;* and of leading them by regular gradations to a general acquaintance with the most essential branches of a sound and liberal education."

The last edition of this volume of the Series, the "Astronomy Made Easy," has been very carefully revised, and many improvements made in it; which, it is hoped, will enhance the good opinion hitherto entertained of it.

PREFACE.

ASTRONOMY is the sublimest science that can occupy the attention of mankind; and it teaches us better how to appreciate the wonderful works of our CREATOR than any other we are acquainted with. Who can raise his eyes to heaven, and, beholding the wonders of the firmament, entertain the least doubt of the existence of a SUPREME BEING? As Mrs. Barbauld beautifully and justly says,

> "We read God's *awful power*, imprinted high,
> With golden letters, on the starry sky."

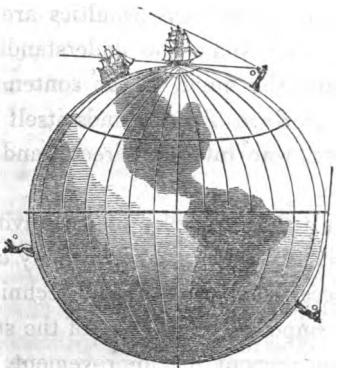
In the heavenly bodies the wisdom of the DEITY manifests itself, and shines on the contemplative mind with a lustre incomparably brighter than that which their united splendours transmit to the eye. The *knowledge* of ASTRONOMY opens to us such a magnificent view of the Creation, that we are struck with astonishment

at the grandeur of the spectacle, and the powers of Omnipotence. By looking abroad into the universe, we exalt our ideas of the Supreme Intelligence, and extend the narrow sphere of human conceptions; the faculties are strengthened and improved; the understanding is enlarged; and the mind, in the contemplation of so many glorious objects, finds itself drawn to that Being, who informs, directs, and animates the whole.

To divest the principles of this divine science of its difficulties, by removing many of the obstacles, occasioned by the use of technical terms, that may impede the progress of the student, or in any way prevent his improvement, has been the main object of the publication of this little work; which, being interspersed with many engravings to elucidate the most difficult facts, and written in a clear and familiar style, the Author trusts will be found adequate for the effect desired.

ASTRONOMY MADE EASY.

Chapter I.



INTRODUCTION.

1. Astronomy is that science which treats of the heavenly bodies, their *motions, periods, eclipses, magnitudes*, &c.; and of the causes on which they depend.

2. That part of the science which relates to the *motions, magnitudes*, and *periods* of *revolution* is called Pure Astronomy; and that which investigates the causes and laws by which these

motions are regulated is called PHYSICAL ASTRONOMY.

3. The *study of this science* is intimately connected with that of GEOGRAPHY, and so beneficial in its effects upon the human mind, that it claims every attention, and deserves the highest admiration.

4. It is by ASTRONOMY that we are taught the knowledge of the HEAVENS; are enabled to range the whole *universe of matter*, and trace the laws by which the SPHERES perform their revolutions, and discharge their office with perfect order and harmony.

5. By the term UNIVERSE is implied the whole frame of nature, to the utmost extent of the creation, comprising all things.

6. Were it possible that we could move whichever way we pleased, and as fast as we could wish, and were to launch out in a direct line from the earth into infinite space, we might fly for thousands of years without meeting with any boundary or limit.

7. In this space, at prodigious distances from one another, we should find various "*Systems of worlds*" revolving round those "CENTRAL SUNS" which we call "FIXED STARS," and which appear small to us because of their great distance.

8. The "SYSTEM OF THE UNIVERSE" (the work of an ALMIGHTY ARCHITECT) is indeed vast, stupendous, and full of wonders. *Man*, when he gazes upon it with attention, must confess his ignorance, and be lost in wonder and amazement.

9. Our SUN is a STAR among the other *stars*, and has *seven worlds* revolving round *him*,—viz. *Mercury*, the nearest; *Venus*, the next; our *Earth*, (and the *Moon*), the next; then *Mars*, *Jupiter*, and *Saturn;* and lastly, the *Georgium Sidus*, discovered by Dr. HERSCHEL.

10. To these may be added the late discovered planets; viz. *Ceres*, *Juno*, *Pallas*, and *Vesta*, which from their being very small, are considered but of minor importance.

11. All the above are called PRIMARY PLANETS, round which revolve eighteen SATELLITES, or MOONS, called SECONDARY PLANETS,—viz. *one* round the EARTH, *four* round JUPITER, *seven* round SATURN, and *six* round the GEORGIUM SIDUS.

12. These compose the regular bodies of OUR SYSTEM.

13. ASTRONOMY is divided into *ancient* and *modern*.

14. ANCIENT ASTRONOMY is that which was

taught by PTOLEMY and his followers, who supposed the Earth quiescent in the centre, and that all the heavenly bodies performed their revolutions round it.

15. MODERN ASTRONOMY is that which has been cultivated since the time of COPERNICUS, who revived the opinions of PYTHAGORAS, and laid the foundation of what is called the "TRUE SOLAR SYSTEM," or "SYSTEM OF THE WORLD."

16. The most celebrated "*Systems of the World*" are the *Ptolemaic*, the *Copernican* or *Pythagorean*, and the *Tychonic*.

17. The PTOLEMAIC SYSTEM is so called from the celebrated *astronomer* PTOLEMY, a native of *Egypt*, who died A. D. 147.

18. In *this system*, the EARTH is supposed to be at rest in the centre of the *Universe*, while the *Heavens* are considered as revolving about it, from east to west, carrying along with them, in the space of twenty-four hours, all the heavenly bodies, the *stars* and the *planets*.

19. This system owed its origin to the sensible appearances of the celestial motions.

20. Imagining the apparent motions of celestial bodies to be absolute, instead of relative, and being unaware that the EARTH had motion

also, the people were of necessity led into erroneous conclusions.

21. They had no idea that every star is the centre of a system, nor of any other WORLD but the EARTH on which we live.

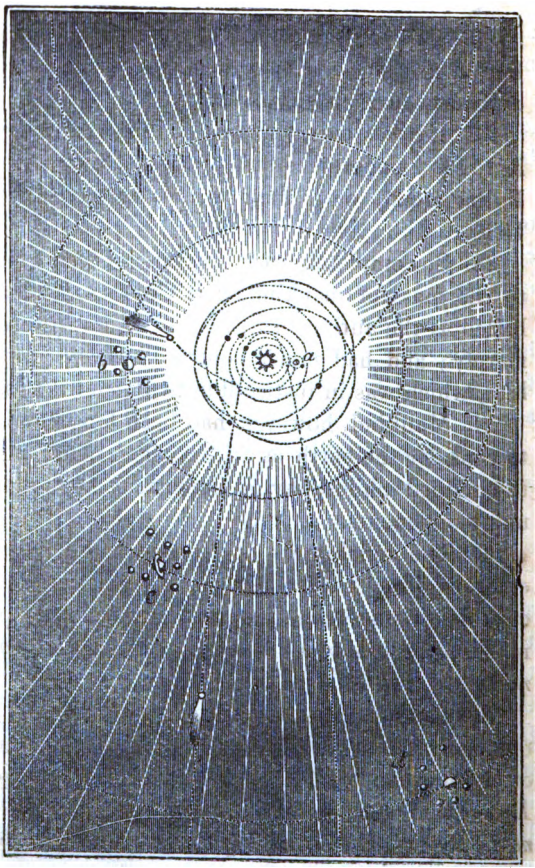
22. They were persuaded that all things were made for the use of man; that all the *stars* were contained in one concave sphere, and, consequently, at an *equal distance* from the *Earth.*

23. But modern observations and discoveries have sufficiently shown the absurdity of this system; so that it is now abandoned by all the learned, and hardly ever mentioned but to be exploded.

24. The principal asserters of this system were *Aristotle, Hipparchus, Ptolemy,* and *Plato.*

INTRODUCTION.—*(Continued.)*

25. The COPERNICAN or PYTHAGOREAN SYSTEM, which is now universally adopted by all the learned in Europe, supposes the SUN to be the *centre of the System,* and the EARTH and all the PLANETS to revolve round him in their orbits; as is represented in the following engraving: in which *a* is our earth and its moon; *b* Jupiter and his Satellites; *c* Saturn with his belt and satellites; and *d* the Georgium Sidus and his Satellites.


b
a

26. This system is so called from the celebrated *astronomer Copernicus*, who was a native of Thorn, in *Polish Prussia*.

27. He was born January 10, 1472, and died in 1543. Copernicus first published the revived Pythagorean, or "*True Solar System*," A. D. 1530.

28. So completely had this system become lost to the mass of mankind, that COPERNICUS was hailed as the author of it, instead of its restorer merely; and had much honour bestowed upon him, which was in justice due to PYTHAGORAS.

29. Mankind, however, had been long taught to consider the earth as an extended plane, and the refined philosophy of Copernicus met with many opponents.

30. The inhabitants of Europe had not yet emerged from *Gothic barbarism*, and were incapable of understanding, and consequently of relishing, the *sublime demonstrations of Astronomy*.

31. The superior learning and just conceptions of *Copernicus* were doomed to give way to the crude notions of TYCHO BRAHE, *a noble Dane*, who, sensible of the defects of the *Ptolemaic System*, but unwilling to acknowledge the

motion of the EARTH, conceived a *New System*, still more absurd than that of PTOLEMY, which it was intended to overthrow.

32. He allowed the MOON a *monthly motion* round the EARTH, as the *centre* of its *orbit*; and made the SUN the *centre* of the *orbits* of the other PLANETS.

33. In conformity to this idea, the *Sun*, with all the planets, turned round the *Earth* once in twenty-four hours; and however repugnant this system was to common sense and sound philosophy, it also met with its admirers.

34. But the light of science soon after began to diffuse itself over Europe, and the mists of error and vulgar prejudice were completely dissipated.

35. The circumstance of Magellan's sailing round the globe, after a voyage of 1124 days, apparently without altering his course, demonstrated the rotundity of the earth, and paved the way to a discovery of its motion.

36. Future navigators did the same; and thus the figure of the Earth was determined with sufficient accuracy; and the discoveries which were perpetually being made by sea, taught the neccssity of attending to ASTRONOMY, as a

science on which NAVIGATION itself depends.

37. Learned men soon sprang up in various nations; among whom were *Kepler*, *Rothman*, *Galileo*, and several others.

38. GALILEO, in 1610, first invented the use of *telescopes;* which, by facilitating *astronomical observations*, tended greatly to the discovery of fresh arguments in favour of the *Earth's* motion, and confirmed those which COPERNICUS had already broached.

39. But superstition still prevailed; and free inquiry was checked, lest it should develop mysteries which it was natural that bigots should wish to preserve secret.

40. The *doctrine* of the *antipodes*, and the *motion* of *the earth*, were conceived by the blind zealots of the church, of that period, to be repugnant to the Scripture records; and GALILEO was charged with heresy, and condemned to die, though in the 70th year of his age; but he recanted his opinions, and thus saved his life.

41. This bigotry of the clergy, however, was not always to prevail, as the Reformation soon taught mankind, that the Scriptures were given as rules of life and guides to everlasting glory,

but not as instructions in the science of philosophy.

42. From the era of the *Reformation*, therefore, we may date the progress of universal science.

43. At the beginning of the last century, the immortal NEWTON, endowed with more than human intelligence, unveiled the works of nature, and displayed the *omnipotence* of the CREATOR, with a splendour of which mankind in general had never formed any just conception.

44. His researches laid open the whole UNIVERSE OF MATTER; he not only explained the motions of the heavenly bodies, but the general laws of nature according to which they move.

45. This law is called GRAVITY, or ATTRACTION; which operates universally through all the regions of matter, retains the *sea* within its shores, and the *rivers* within their banks; keeps the PLANETS within their *orbits*, and preserves the whole fabric of nature in perfect harmony and order.

46. And here, who can sufficiently admire the DIVINE WISDOM and POWER conspicuous in all the works of OMNIPOTENCE!

47. What august, what amazing conceptions must fill the mind of man, on surveying the thousands of worlds which roll around us in rapid motion; yet calm, regular, and harmonious!

48. And if the magnificence displayed in the material creation, which is the least considerable of the works of *God*, strikes us with such wonder and delight, how great, wise, and bountiful must that Power be which first called it into existence!

49. The order in which the PLANETS revolve round the SUN according to the COPERNICAN SYSTEM is the following; viz. MERCURY, VENUS, the EARTH, attended by her secondary, the *Moon;* MARS, JUPITER, SATURN, and the GEORGIUM SIDUS.

50. These, together with their several *satellites*, the COMETS, and the four MINOR PLANETS, which have been lately discovered, viz. *Ceres*, *Pallas*, *Juno*, and *Vesta*, constitute what is called the "SOLAR SYSTEM."

See plate, page 6, where this system is represented, by which an adequate idea of the whole may be easily obtained.

51. *Obs.* That all the SATELLITES move round their respective *primaries* in the same manner as the *Moon* revolves round the *Earth*.

52. The TYCHONIC SYSTEM was taught by the celebrated TYCHO BRAHE, a native of *Denmark*, who was born in 1546.

53. THIS SYSTEM supposes that the EARTH is fixed in the centre of the universe or firmament of stars, and that all the stars and planets revolve round the Earth in twenty-four hours; but it differs from the PTOLEMAIC SYSTEM, as has been before explained.

EXPLANATORY REMARKS.

2. PHYSICAL signifies any thing relating to physics, which is a term denoting the same as natural philosophy; being the doctrine of natural bodies, their phenomena, causes, and effects, &c.

14. QUIESCENT means at rest, not changing place.

22. CONCAVE signifies hollow, as applied to the inner surface of a circular body, such as the inner side of an egg-shell, &c.

40. ANTIPODES (pron. An-tip-o-dees) is a term derived from two Greek words, *anti*, against, and *podes*, the feet: it is applied to those persons who live on the contrary side of the globe, with their feet directly opposite to ours.

HERESY has two meanings: in a good sense, it implies a sect or collection of persons holding the same opinion; and in a bad sense, it signifies a sect or number of persons separating from and opposing the doctrine of the *Catholic* Church: the latter is its signification in this chapter.

RECANT means to retract, to contradict what one has professed, said, or done.

41. REFORMATION denotes the change of religion from the

corruption of Popery to its primitive state; which commenced in the early part of the sixteenth century.

45. GRAVITY is the power or virtue by which bodies naturally tend to the centre. It also means weight, heaviness; and when applied to the countenance, seriousness, solemnity, majesty.

QUESTIONS FOR EXAMINATION.

1. What is astronomy?
2. What is *pure* astronomy? What, *physical* astronomy?
3. With what is the study of this science connected?
4. What knowledge are we taught by astronomy?
5, 6. What is understood by the term *universe*?
7. What should we find in this space?
8. Of what extent is the "*system of the universe*?"
9. What is our sun? and what other worlds revolve round him?
10. What other planets may be added?
11. What are all the above called? and what revolve round them?
12. What do these compose?
13. How is astronomy divided?
14. What is ancient astronomy?
15. What, modern?
16. What are the most celebrated "systems of the world?"
17. Why is the Ptolemaic system so called?
18. What is considered in this system?
19. To what did this system owe its origin?
20. What was taken for granted?
21. What is easy to observe?
22. What were they persuaded?
23. What have the modern discoveries sufficiently shown?
24. Who are the principal assertors of this system?
25. What is the Copernican or Pythagorean system?
26. Why was this system so called?
27. When was he born? when did he die?

28. Who was the inventor of this system? who, only the restorer?

29, 30, 31. Did the philosophy of Copernicus meet with many opponents? To what did it give way?

32. What did Tycho Brahe allow?

33. What did the sun in conformity with this idea? Did his system meet with any admirers?

34. What diffused itself soon after over Europe? and what were dissipated?

35. What circumstance demonstrated the rotundity of the earth?

36. What taught the necessity of attending to *astronomy*?

37. What learned men soon sprang up?

38. What did Galileo first invent?

39. What still prevailed? and why was free inquiry checked?

40. What was this doctrine considered by the zealots of the church?

41. What did the Reformation soon teach mankind?

42. What may we date from this era?

43. What did the immortal Newton at the beginning of the last century?

44. What did his researches lay open? and what did he explain?

45. What is this law called? Through what does it operate?

49. In what order do the planets revolve round the sun according to the Copernican system?

50. What constitute the "*solar system*?"

51. In what manner do the satellites move round the sun?

52. By whom was the Tychonic system taught?

53. What does this system suppose?

Chapter II.

OF THE DIVISION OF THE HEAVENS.

1. The Heavens are divided by *Astronomers* into three regions; viz. the *Zodiac*, and the *Northern* and *Southern Hemispheres*.

2. The *annual revolution* of the Earth causes an apparent motion of the Sun through the heavens.

3. The line in which the Sun appears to move is called the Ecliptic.

4. It obtained this name, because all eclipses of the Sun and Moon happen when the Moon appears in or near it.

5. The Zodiac* is an imaginary broad circle or *belt* encompassing the heavens, and extending *eight degrees* on each side of the *ecliptic*.

6. Within the bounds of the *Zodiac* all the planets make their excursions.

7. The Zodiac is divided into twelve equal parts, called *signs*, each containing thirty degrees.

* It is so called from a Greek word, which signifies an *animal*; the signs of the Zodiac consisting chiefly of the figures of animals.

8. These signs are twelve clusters of stars, called constellations

9. A *constellation* is a number of stars which appear to lie in the neighbourhood of one another on the surface of the celestial sphere, and which ASTRONOMERS, for their easy remembrance, suppose to be circumscribed with the outlines of some animal or other figure, and whereby the motions of the planets are more readily described and composed.

10. Those stars which are not included in any constellation are called *unformed stars.*

11. *Six* of these signs are on the north side of the equinoctial line, and *six* on the south.

12. The northern signs are *Aries,* the ram; *Taurus,* the bull; *Gemini,* the twins; *Cancer,* the crab; *Leo,* the lion; and *Virgo,* the virgin.

13. The southern signs are *Libra,* the balance; *Scorpio,* the scorpion; *Sagittarius,* the archer; *Aquarius,* the waterman; and *Pisces,* the fishes.

14. All those constellations which lie on the north side of the *ecliptic* are in the *northern* hemisphere; those on the south side of it are in the *southern* hemisphere.

15. The EQUATOR divides the *northern* and

southern hemispheres on the EARTH; the ECLIPTIC divides *them* in the HEAVENS.

16. The NORTHERN HEMISPHERE contains *thirty-six* constellations; the SOUTHERN *thirty-two;* and the ZODIAC, *twelve;* making in the whole *eighty* constellations.

17. In consequence of the *diurnal revolution* of the EARTH, the WHOLE HEAVENS *appear* to have a diurnal revolution on the axis of the equinoctial; that is, a diurnal revolution round the Earth.

18. The celebrated astronomers mentioned in the last chapter flourished as follows; viz. PYTHAGORAS, who was born at SIDON, in *Syria*, 590 years before Christ; PTOLEMY, who was born in EGYPT about the year 70 of the Christian era; COPERNICUS, who was born at THORN, in *Prussia*, in 1472.

19. GALILEO was born at FLORENCE, in *Italy*, in 1564; and NEWTON was born at WOOLSTROP, in *Lincolnshire*, in 1642. But the first who demonstrated the laws which govern the heavenly bodies was the incomparable Sir ISAAC NEWTON.

20. Thus arose the system on which the GREAT NEWTON so justly raised the fabric of his immortality.

21. It is to this great luminary we are indebted for the knowledge of those different motions that form and keep the EARTH and the OTHER PLANETS in their respective *orbits;* the *gravitation* which binds the component particles of each world together; and the *ebbing* and *flowing* of the TIDES.

22. To him we also owe the knowledge we have of the *cause* and *progress* of LIGHT; and of the *origin* and *nature* of COLOURS; and above all, to him are we indebted for our belief that there exists a POWER which has created every STAR a SUN, with a SYSTEM of *different worlds revolving round it.*

23. The *orbit* of a planet is the path in which it moves. The orbits of the planets are not *circular,* but *elliptical.*

24. The GLOBE or EARTH on which we live, and which to us appears the centre of this great fabric, is, in effect, but a small part of it, a mere *speck,* as it were, in the vast map of the universe.

25. OUR GLOBE is but one of the *seven planets* that revolve round the *Sun* as their *common centre.*

26. The SUN, which is a vast *orb,* exceeding

a million of times the size of our Earth, is placed at the immense distance of ninety-six millions of miles from us; and at this distance we travel round the *Sun* in the space of a year.

27. Beyond the *solar* or *planetary system*, are placed the FIXED STARS, whose distance is so immense that no mortal art has ever traced it.

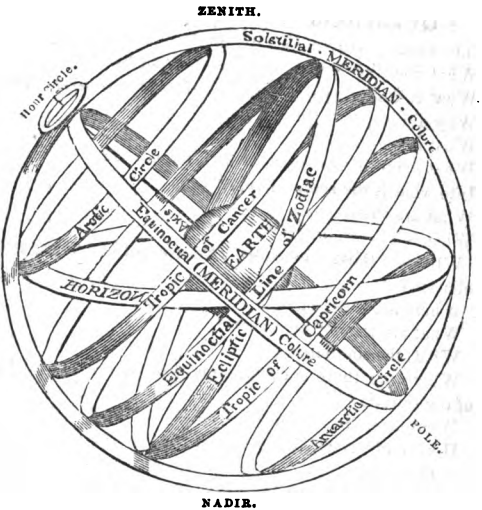
28. Here let it be observed, that all the planets revolving round the SUN are, in effect, dark and opaque bodies, or *other* EARTHS, shining only with the light which they receive and reflect from him.

29. This is the case with the Moon, whose different appearances, such as *new*, *full*, *horned*, &c., are all owing to her different situations with regard to the SUN; at the *full*, *she* always *rises* when HE *sets*, and *sets* when HE *rises*.

30. The ARMILLARY* SPHERE, a name given to the artificial sphere, is composed of a number of circles of metal, wood, or paper, which represent the several circles of the *System of the World*, put together in their natural order; as exemplified in the following engraving.

* ARMILLARY is derived from the Latin *Armilla*, a bracelet or ring.

ARMILLARY SPHERE.



EXPLANATORY REMARKS.

1. HEMISPHERE is derived from two Greek words, *hemi*, meaning half, and *sphaira*, a sphere; it signifies one half of the globe.

9. CIRCUMSCRIBED means enclosed in certain lines or limits: bounded.

17. DIURNAL signifies daily.

21. LUMINARY signifies any body that gives light; and, *figuratively*, it is applied to a person who makes discoveries and communicates them.

28. OPAQUE means dark, having no light in itself; not to be seen through.

QUESTIONS FOR EXAMINATION.

1. Into what do astronomers divide the heavens?
2. What does the earth's annual revolution cause?
3. What is that line called in which the sun appears to move?
4. Why did it obtain this name?
5. What is the zodiac?
6. What make their incursions within the zodiac?
7. Into what is the zodiac divided?
8. What are these signs?
9. What is a constellation?
10. What are those stars called that are not included in any constellation?
11. Where are these signs?
12. What are the northern signs?
13. What, the southern?
14. Where are those constellations that lie on the northern side of the *ecliptic*?
15. What does the *equator* divide?
16. How many constellations are there in the northern hemisphere? How many, in the southern? How many, in the zodiac?
17. What revolutions do the whole heavens appear to have in consequence of the diurnal revolution of the earth?
18, 19. When did the celebrated astronomers mentioned in the last chapter flourish?

Who was the first that demonstrated the laws of the heavenly bodies?

20. What system did thus arise?
21. For what knowledge are we indebted to this great luminary?
22. What knowledge also do we owe to him?
23. What is the orbit of a planet?
24. What does our globe appear to us? What is it in effect?
25. What is our globe?
26. How far is the sun from us?

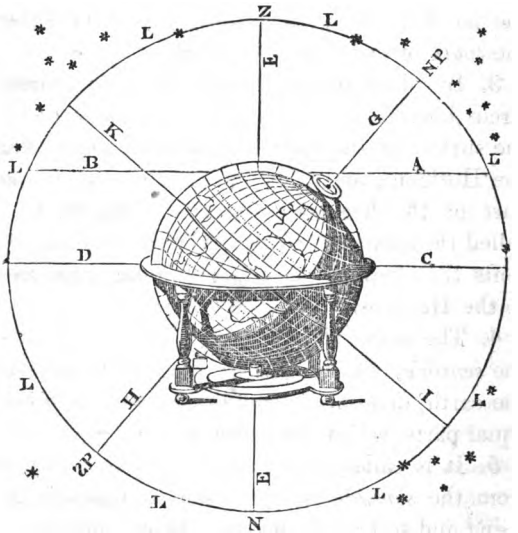
27. What stars are placed beyond the solar or planetary system

28. What kind of bodies are the planets?

29. To what does the moon owe its different appearances?

30. What is the *Armillary* sphere?

Chapter III.



EARTH AND HEAVENS.

1. As the Earth turns round in the space of nearly twenty-four hours, a line has been ima-

gined to pass through it, upon which it turns, as a wheel upon its axis. This line is called the earth's *axis;* and is shewn by G H in the above engraving.

2. The two extremities of this line, carried to the Heavens, are the two poles; one is called the *north* or *arctic pole,* N P; and the other the *south* or *antarctic pole,* S P.

3. In observing the Heavens, an apparent circle bounds our view, and appears to touch the surface of the Earth; this Astronomers call the Horizon; and from its dividing the visible part of the heavens from the invisible, it is called the *sensible horizon.* The line B A represents the *sensible horizon* of London produced to the Heavens.

4. The *rational horizon* is a circle parallel to the *sensible,* and passes through the centre of the earth, dividing it and the heavens into two equal parts, called *hemispheres.*

5. It is called the *rational,* to distinguish it from the *sensible,* and is used to indicate the rising and setting of the Sun, Moon, and Stars; it is represented by D C.

6. The *axis* of the horizon is an imaginary line passing perpendicular and at right angles to

the planes of the *sensible* and *rational horizons*, as E E.

7. The extremes of this axis are called the *poles* of the horizon; the one over the head of the spectator is called the *zenith*, Z; and the other, which is under his feet, is called the *nadir*, N.

8. The *great circle* which passes round the centre of the earth, perpendicular to its axis, and at an equal distance from either pole, is called the *equator*. It is represented in the engraving by I K, and is produced to the *starry firmament*, which is denoted by L, and is there called the *celestial equator*.

9. The *equator* cuts the earth into two equal portions, called the northern and southern hemispheres, and it is divided into 360 parts, called degrees. By these degrees are measured the longitudes of all places upon the earth's surface.

10. The *meridian* is a great circle, dividing the earth into equal parts, called the eastern and western hemispheres, at the same time passing through both the north and south poles. The Sun is always in it at noon.

11. The *ecliptic* is another great circle, which intersects the equator at an inclination of about

twenty-three degrees (see plate, page 20). It is the apparent path of the Sun.

12. About eight degrees on each side of the ecliptic is the *zodiac*, which is a kind of broad belt or girdle, within which the motions of all the planets are performed.

13. The *ecliptic* and *zodiac* are divided into twelve equal parts, called *signs*, each containing about thirty degrees; the progress of the Sun through the ecliptic is nearly a degree in a day.

14. The two points where the *ecliptic* cuts the *equator* are called the *equinoctial* points; when the Sun is at these points, the days and nights are equal all over the globe.

15. This occurs about March 20th, and September the 23d; the former period is called the *vernal equinox*, and the latter the *autumnal*.

16. The points of the *ecliptic*, at the greatest distance from the *equator*, are called the *solstices*, which term signifies the *standing still of the Sun*.

17. About the 21st of June, the Sun having reached his highest altitude, alters his position for some days very little indeed, and on this account that period is called the *summer solstice*, or standing still of the Sun.

18. About the 21st of December, the Sun is in his lowest position; when he is again stationary a day or two: and passes the period termed the *winter solstice.*

19. These two *solstitial* points are called the *tropics,* and the circles passing through them, the *tropical circles.*

20. These circles are parallel to the equator, and are called, the one in the north, the *Tropic of Cancer;* and the one in the south, the *Tropic of Capricorn.*

21. The former is called *Cancer,* from the Sun being at that period in the sign of the zodiac named *Cancer;* and the other, *Capricorn,* from the Sun entering that sign at the winter solstice.

QUESTIONS FOR EXAMINATION.

1. Upon what does the earth turn?
2. What are the extremities of the earth's axis?
3. What bounds our view of the heavens?
4. What is the *rational horizon?*
5. Why are they called *rational* and *sensible?*
6. What is the *axis* of the horizon?
7. What are the *poles* of the horizon?
8. What is the *equator?* What, the celestial *equator?*
9. What is the use and effect of the equator?
10. What is the *meridian?*
11. What is the *ecliptic?*

12. What occupies each side of the ecliptic?
13. How are the ecliptic and zodiac divided? What is the sun's progress in the *ecliptic*?
14. What are the *equinoctial* points?
15. When do these periods occur?
16. What are the *solstices*?
17. When is the *summer solstice*?
18. When, the *winter solstice*?
19. What are the *solstitial* points called?
20. What are these circles called?
21. Why is the one called *Cancer*? and the other, *Capricorn*?

CHAPTER IV.

OF THE FIXED STARS.

1. NOTHING gives such enlarged ideas of the immensity of the UNIVERSE as do the number and magnitude of the FIXED STARS, and their distance from us, and from one another.

2. Among the many distinctions which characterise them from the *other luminaries* of HEAVEN, that which is afforded by their *light* or *peculiar lustre* is the most obvious.

3. The *light* of the PLANETS is steady, because it is *reflected;* but that of the FIXED STARS is *bright* and *lively*, and accompanied with an *appearance* which we call *twinkling*.

4. They form no part of the "SOLAR SYSTEM;" nor is it to be imagined that they are placed in one *concave surface*, so as to be all equally distant from us, but that they are dispersed through *unlimited space*, in such a manner, that there may be as *great* a distance between any *two neighbouring stars*, as there is between our SUN and that which is nearest to him.

5. The difference in the apparent magnitude of the stars is such as to admit of their being distinguished into *different* CLASSES: the *largest* being called STARS of the *first magnitude;* those that appear something *less*, of the *second magnitude;* and so on to the *sixth*, which include all the STARS that are visible to the naked eye. Those which cannot be seen without glasses are called TELESCOPIC STARS.

6. The *number* of STARS of the *first magnitude* is about twenty; of the *second*, sixty-five; of the *third*, two hundred and five; of the *fourth*, four hundred and eighty-five; of the *fifth*, six hundred and forty-eight; and of the *sixth*, one thousand four hundred and twenty: in all, nearly three thousand.

7. Of these stars, not more than one thousand

can be seen with the *naked eye* at one time in either hemisphere; their *seeming innumerable* at first sight arises from our viewing them confusedly, and without reducing them to any order.

8. If they are viewed distinctly, and only a small portion at a time; after some attention to the situation of the remarkable stars contained in that portion; we shall be surprised, upon attempting to count them, at the smallness of their number, and the ease with which they may be enumerated.

9. In order that the Stars may be distinguished and pointed out according to their true positions and situations, they have long been classed under the outlines of certain imaginary figures of *beasts*, *birds*, and other *animals*, which are called CONSTELLATIONS (as before observed), each containing such stars as are situated near each other.

10. The division of the ZODIAC into *twelve signs* has a relation to the twelve months in the year; and the animals by which they are represented are the EMBLEMS of the different productions of nature in those seasons over which they preside.

11. Many of the other Constellations which

are without the Zodiac, appear to have been formed in honour of certain *heroes*, and celebrated *personages*, whose memory they were meant to perpetuate.

12. Besides the names to these Constellations, particular appellations are given to smaller collections of Stars, and even to some of the most remarkable single ones.

13. Thus, the cluster of small Stars in the neck of *Taurus* is called the PLEIADES; the seven Stars in the *Great Bear*, CHARLES'S WAIN; and the Star in the extremity of the tail of the *Little Bear*, the NORTH POLE STAR.

14. The star in the mouth of *Canis Major*, the Great Dog, is called SIRIUS; which is supposed to be eighteen *billions* of miles from the EARTH, and is reckoned to be the nearest to it.

15. There is no change in the apparent situation of the Stars when viewed from opposite sides of the *Earth*, nor even when they are viewed from different sides of the *Earth's orbit*; therefore, their distance must be immense.

16. The number of the fixed Stars discovered by the *telescope* is very great; but their amount can never be ascertained, as every improvement in that instrument increases the number.

17. The *milky way*, called the *Galaxy*, may be considered as a constellation; since it is but an immense collection of fixed stars; and which, from their immense distance, require telescopes of great magnifying power to be observed.

QUESTIONS FOR EXAMINATION.

1. What give us the most enlarged idea of the structure and magnificence of the heavens?

2. What is their most obvious distinction?

3. What difference is there in the *light* of the planets and the fixed stars?

4. No part of what do they form? How are they dispersed?

5. Into how many classes are the stars divided?

6. What is the number of stars of each magnitude? What, altogether?

7, 8. How many are visible to the naked eye at one time? What causes their seeming to be innumerable?

9. Under what outlines have the stars been classed? Why?

10. To what has the division of the zodiac into twelve signs a relation?

11. For what do many of the other constellations appear to have been formed?

12. To what are particular appellations also given?

13. What is the cluster of small stars at the neck of *Taurus* called? What, the seven stars in the *Great Bear*? What, the star at the extremity of the tail of the *Little Bear*?

14. What is the star in the mouth of the *Canis Major* called? At what distance is this star supposed to be from the earth?

15. Is there any change in the apparent situation of the stars?

16. What is the number of the fixed stars discovered by the telescope?

17. What is the *milky way*, or *galaxy*?

CHAPTER V.

OF THE SOLAR SYSTEM.

1. THE SOLAR SYSTEM is contained within that part of the universal space called "THE VISIBLE WORLD," and consists of the SUN, the *planets, satellites* or *moons, asteroids,* and an uncertain number of *comets.* *(See plate, page 6.)*

2. All the *planets, satellites, asteroids,* and *comets* are solid, opaque, globular bodies, of different magnitudes, and receive their *light* and *heat* from the SUN, which they reflect upon each other in the same manner as a polished body does that of a candle; and by which means they become visible to us.

3. The *names* of the SEVEN PLANETS, with their signs, in their order from the SUN (☉), are, *Mercury* (☿), *Venus* (♀), the *Earth* (⊕) with its *moon* (●), *Mars* (♂), *Jupiter* (♃) with his four *moons, Saturn* (♄) with his seven *moons,* and the *Georgium Sidus* (♅) with its *moons.*

4. MERCURY (☿) and VENUS (♀) move within the orbit of the *Earth* (⊕), and are in consequence called "*Inferior Planets;*" the others move on the outside of its orbit, and are called "*Superior Planets.*"

5. There are *four* minor planets that have been discovered in the present century, whose *orbits* are between those of *Mars* (♂) and *Jupiter* (♃); they are CERES, PALLAS, JUNO, and VESTA; but from their inconsiderable size, the largest being much less than our *Moon*, they have been esteemed but of little importance; hence Dr. HERSCHEL has named them *Asteroids*.

6. The term *Asteroid* is derived from two Greek words, *aster*, a star, and *eido*, I see; and signifies *appearing* like a star: they are so called only on account of their minuteness.

7. To be seen distinctly, they require glasses of a highly magnifying power.

8. CERES, the largest, was discovered by PIAZZI, at *Palermo*, in 1801; its diameter is seventeen hundred and sixty miles, that of the *Earth* is seven thousand nine hundred and seventy.

9. PALLAS, the *second*, was discovered by Dr. OLBERS, at *Bremen*, in 1802.

10. JUNO, the *third*, by Mr. HARDING, at *Lilienthal*, near *Bremen*, in 1804; and VESTA, the *fourth*, by Dr. OLBERS, in 1807.

11. All the *Planets*, and their several *moons*, or *satellites*, revolve round the SUN as their common centre, and in the manner shown in the plate, *page* 6.

12. The Planets which revolve round the *Sun* alone, are called *primary planets;* and those which revolve round the planets, and travel with them round the Sun, as our Moon does round the earth, are called *secondary planets.*

13. It has been already noticed, that there is an inconceivable number of *Suns, Systems,* and *Worlds* dispersed throughout the UNIVERSE; insomuch that our "SOLAR SYSTEM," compared with the whole, is a mere *speck,* or *atom,* and almost lost in the immensity of the creation.

QUESTIONS FOR EXAMINATION.

1. In what is the solar system contained? and of what does it consist?
2. What kind of bodies are the *planets, satellites, asteroids,* and *comets?* Whence do they receive their *heat* and *light?*
3. What are the names of the seven planets?
4. What sort of planets are *Mercury* and *Venus* called? What, the other planets?
5. What minor planets have been discovered? Of what size?
6. Whence is the term *asteroid* derived?
7. What do they require to be seen distinctly?
8. When and by whom was *Ceres* discovered?
9. By whom and when was *Pallas* discovered?
10. By whom and when, *Juno? Vesta?*
11. What motion has the planets?
12. Into what are the planets distinguished?
13. What is our *solar system,* compared with the whole *universe?*

Chapter VI.

OF THE SUN (☉).

1. The SUN is an immense globe or ball, a *million* of *times* larger than the EARTH, and five hundred times larger than all the planets put together.

2. Its *diameter* is eight hundred and ninety thousand miles, and its distance from the Earth is ninety-six millions of miles.

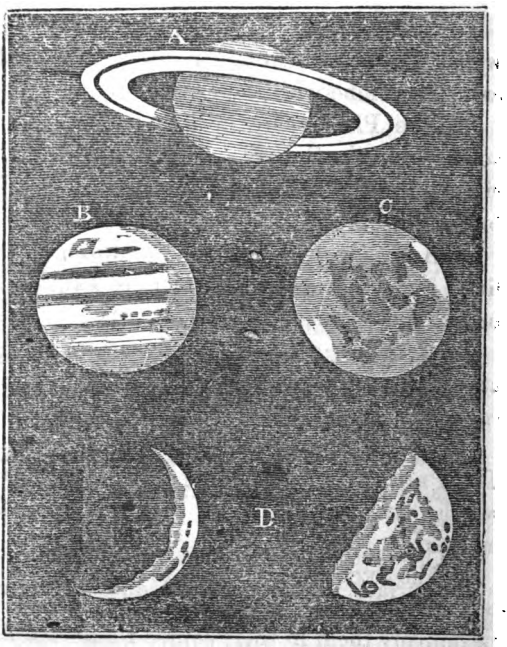
3. The SUN is the FOUNTAIN of *light* and *heat*, the PARENT of the *seasons*, and the CAUSE of *day* and *night*.

4. The only *motion* of the SUN is that round its axis, which it performs in twenty-five days, six hours.

5. This revolution was discovered by the spots on its surface, which are seen only at certain periods, according to the Sun's motion.

QUESTIONS FOR EXAMINATION.

1. What is the sun? What is its magnitude?
2. What is its diameter?
3. Of what is the sun the *fountain*? the *parent*? and the *cause*?
4. What motion has the sun?
5. How was this revolution discovered?



Chapter VII.

OF THE PLANETS.

1. **Planets** are those celestial bodies which change their situation; whereas the Stars always remain fixed.

2. The PLANETS shine with a steady light, which they receive from the SUN; but the *Sun* and *Stars* shine with their own light.

3. The Planets are opaque bodies, and revolve round the Sun as a centre, in orbits nearly circular: the COMETS also move round the *Sun*, but in very *eccentric ellipses*.

4. An *Ellipsis* is a regular continued curve-line, including a space which is longer than broad, and commonly called an *oval*.

5. *Eccentric* signifies the departing or deviating from a centre, or not having the same centre with a circle.

6. PLANETS are either *primary* or *secondary*. The PRIMARY PLANETS are those *larger bodies* which have the Sun for the centre of their motion.

7. The SECONDARY PLANETS are those smaller bodies, which revolve about the *primaries*, and accompany them in their course round the Sun: they are also called *Moons* or *Satellites*.

8. The PRIMARY PLANETS, with their signs, are *Mercury* (☿), *Venus* (♀), the *Earth* (⊕), *Mars* (♂), *Jupiter* (♃), *Saturn* (♄), and the *Georgium Sidus* (♅), which last is sometimes called *Herschel*, from its discoverer and some-

times *Uranus*. This planet was discovered in 1781.

QUESTIONS FOR EXAMINATION.

1. What are planets?
2. With what light do the *planets* shine? The fixed stars?
3. How and round what do the *planets* revolve? How and what, the *comets*?
4. What is an *ellipsis*?
5. What does *eccentric* signify?
6. What are primary planets?
7. What, secondary?
8. Name the primary planets.

CHAPTER VIII.

MERCURY (☿).

1. THE planet MERCURY is the nearest body to the *Sun* with which we are acquainted.

2. Its *mean* distance from the Sun is about thirty-seven millions of miles, round which it revolves in about three months, at the rate of one hundred and ten thousand miles per hour.

3. MERCURY is the smallest of all the *planets*, being only three thousand two hundred and sixty miles in diameter.

4. The time of its diurnal revolution has not been ascertained; which arises from its being lost in the splendour of the Sun.

5. MERCURY is seldom to be seen with the naked eye; but with glasses it appears extremely brilliant, and has all the phases or appearances which are common to the moon.

6. When MERCURY comes between the *Earth* and *Sun*, it appears like a black spot passing over the *Sun's disc*.

7. This planet is never to be seen more than *two hours* before the RISING of the Sun, and *two hours* after his SETTING.

8. MERCURY can never be seen entirely round, or at its full; because its enlightened side is never turned directly towards us, except when it is so near the Sun as to be hidden in his beams.

EXPLANATORY REMARKS.

2. MEAN signifies wanting dignity, of low birth or rank—also intervening, intermediate; in *astronomy*, when applied to the motion of the sun, moon, or planets, it signifies that which would take place if they moved in a perfect circle, and equally every day.

3. DIAMETER is the imaginary line which passes through the centre of a circle, &c. and divides it into two equal parts.

5. PHASES are the several appearances observed in the planets.

6. DISC, in *astronomy*, is the face of the sun, moon, or any planet, as it appears to the eye. In *optics*, it is the magnitude of

the glass of a telescope, or the width of its aperture. In *botany*, it is the central or midde part of radiated flowers, composed of several florets placed perpendicularly, and sometimes called the *pelvis* or *basin*.

QUESTIONS FOR EXAMINATION.

1. How near is Mercury to the sun?
2. What is its *mean* distance from the sun? and what its revolution round him?
3. What is its diameter?
4. What is the time of its diurnal revolution?
5. What is the appearance of Mercury?
6. Like what does it appear when between the earth and the sun?
7. How long and when is this planet to be seen?
8. Can Mercury ever be seen at its full?

CHAPTER IX.

VENUS (♀).

1. VENUS is the next planet to *Mercury* in order from the *Sun*.

2. The *mean distance* of VENUS from the SUN is about sixty-nine millions of miles, and she moves at the rate of eighty thousand miles per hour.

3. She is something less than the *Earth*, being only seven thousand six hundred miles in dia-

meter; and revolves on her axis in twenty-three hours, twenty-two minutes.

4. When she appears on the *West* side of the SUN, she rises before him in the morning, and is called PHOSPHORUS, or the *Morning Star;* and when she appears on the *East* side of that luminary, she shines in the evening, and is then called VESPER, or the *Evening Star.*

5. VENUS, as well as MERCURY, when viewed through a TELESCOPE, does not appear round. This is owing to her enlightened side never being wholly turned towards us, except when she is directly on the other side of the Sun, and then she cannot be seen.

6. When this planet is viewed through a *telescope,* she appears to have all the phases common to the *Moon.*

7. VENUS can never be seen more than three hours and a quarter, either before the Sun rises, or after he sets.

EXPLANATORY REMARKS.

4. PHOSPHORUS, also PHOSPHOR, is derived from two Greek words—*phos*, light, and *phero*, I bring: hence is the term applied to VENUS when she goes before the sun. It is the name also of a chemical substance, which when rubbed or exposed to the air takes fire.

VESPER is the Latin word for evening; and, in consequence, it is applied to VENUS when she sets after the sun.

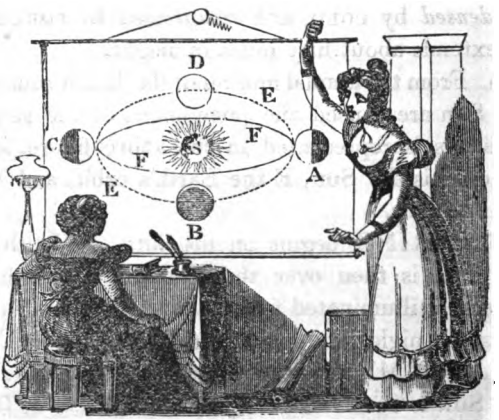
QUESTIONS FOR EXAMINATION.

1. What is the situation of Venus?
2. What is her mean distance from the sun? and at what rate does she move?
3. What is the size of Venus?
4. When is she called the *morning* star? When the *evening* star?

5, 6. How does Venus appear when viewed through a telescope?

7. How long, and when can Venus be seen?

CHAPTER X.



OF THE EARTH (⊕).

1. THE next planet to *Venus* from the SUN is the EARTH, which moves round the Sun in

three hundred and sixty-five days, five hours, and forty-eight minutes.

2. Its mean distance from the Sun is ninety-six millions of miles, and it moves at the rate of sixty-eight thousand miles an hour.

3. The EARTH is encompassed with a thin transparent invisible fluid, called the *atmosphere* or *air*, which partakes of its annual and diurnal motions.

4. It is capable of being *expanded* by HEAT, *condensed* by COLD, and *compressed* by FORCE. It extends about fifty miles in height.

5. From the annual motion of the Earth round the Sun are caused the phenomena of the seasons; as is represented in the above figure, in which S is the Sun, E the Earth's orbit, and F the Equator.

6. SPRING begins on the 20th of March: the SUN is then over the Equator at C, the EARTH is illuminated from pole to pole, and the days and nights are equal throughout the world.

7. SUMMER begins on the 21st of June: the SUN is then over the *Tropic of Cancer* at B, the north frozen zone is illuminated, we have *long days* and *short nights*, and the south frozen zone is involved in darkness.

8. AUTUMN begins on the 22d of September: the SUN is returned to the *Equator*, at A; when the days and nights again become equal throughout the world.

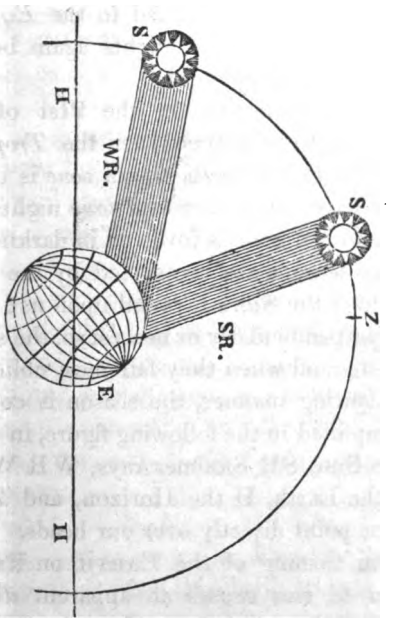
9. WINTER begins on the 21st of December: the SUN is then over the *Tropic of Capricorn* at D, the *south frozen zone* is illuminated, we have *short* days and *long* nights, and the north frozen zone is involved in darkness.

10. The seasons are occasioned by the direction in which the Sun's rays fall upon us; when they fall perpendicularly or nearest so, the season is warmest; and when they fall most obliquely, or in a slanting manner, the season is coldest: as is exemplified in the following figure, in which S S is the Sun, S R Summer rays, W R Winter rays, E the Earth, H the Horizon, and Z the Zenith, or point directly over our heads.

11. The turning of the EARTH on its axis *from west* to *east* causes an apparent *diurnal motion* of the SUN and STARS from *east* to *west*.

12. That part of the earth which is turned towards the Sun during the revolution on its own axis *has day*, and the other part *night*.

13. This planet is attended by one satellite or secondary planet, called the *Moon*. The



Earth's diameter is seven thousand nine hundred and seventy miles. It turns round its axis once in twenty-three hours, fifty-six minutes, and four seconds.

QUESTIONS FOR EXAMINATION.

1. Which planet is next to Venus? How long is the earth moving round the sun?
2. What is its mean distance from the sun? and at what rate does it move?
3. With what is the earth encompassed?
4. Of what is the atmosphere capable?
5. What phenomena are caused by the earth's annual motion?
6. When does *spring* begin? and where then is the sun?
7. When, *summer*? and where, the sun?
8. When, *autumn*? and where, the sun?
9. When, *winter*? and where is then the sun?
10. By what are the seasons occasioned?
11. What apparent motion does the earth's turning on its axis cause?
12. What part of the earth has *day*? and what *night*?
13. By what is this planet attended? what is its diameter? and how long is it turning on its axis?

CHAPTER XI.

OF THE MOON (☾).

1. THE MOON is a constant attendant on the EARTH, which she regards as her centre, and in whose vicinity she incessantly remains.

2. Her mean distance from the *Earth* is two hundred and forty thousand miles; her *diameter* is about two thousand one hundred and eighty,

and she moves at the rate of two thousand three hundred miles an hour.

3. Next to the SUN, the Moon appears to us the most splendid and shining globe in the heavens.

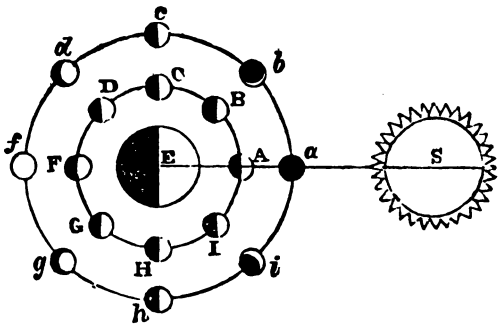
4. It is the Moon that regulates the flux and reflux of the sea; that is, the flowing and ebbing of the tide. (*See page* 72.)

5. She is not only a pleasing, but a very welcome object; and is of great use to the navigator, the traveller, and the husbandman.

6. When the Moon is viewed through a telescope, her surface appears rough and full of mountains and valleys. (*See* C l), *engraving, page* 36.)

7. She appears much larger to us than any of the other planets, on account of her being much nearer to us.

8. The different phases of the moon are exemplified in the following figure; in which S represents the Sun, E the Earth, A, B, C, D, &c., the moon in different parts of her orbit, and *a, b, c, d,* &c. her several phases or appearances as seen by us at E.



9. When the Moon changes, as at A, its dark side will be towards the Earth; consequently, she will appear to us as represented at *a*, if she be seen at all; when at B she will appear to us as at *b*; when at C, as at *c*; as so on till she arrives again at A; her illuminated side increasing gradually to F, whence it decreases as gradually till she becomes again invisible at A: at F her illuminated side being towards us, we have therefore a full Moon as at *f*.

10. The EARTH may be considered as a *satellite* to the MOON.

QUESTIONS FOR EXAMINATION.

1. To what is the moon a constant attendant? As what does she regard the earth?

2. What is her mean distance from the earth? her diameter? and the rate of her motion?

3. What is the appearance of the moon to us in regard to the sun?

4. What does the moon regulate?

5. To whom is she of great use?

6. What is the appearance of the moon's surface when viewed through a telescope?

7. Of what size does she appear to us?

10. What may the earth be considered to the moon?

CHAPTER XII.

OF ECLIPSES.

1. AN ECLIPSE is the privation of light in any of the heavenly bodies, of which the most common to us are those of the *Sun* and *Moon*.

2. Eclipses were, in former ages, beheld with terror and amazement, and considered to portend some great calamity and misery to mankind; but since the advancement of science we are delivered from these fears and idle apprehensions.

3. The SUN is *eclipsed* when the MOON passes in a direct line between the EARTH and the Sun, which can never happen but at the time of a *new Moon:* the eclipse begins on the SUN'S *Western side*, and goes off on his *Eastern*.

4. The MOON is eclipsed when she is opposite to the SUN, or has the EARTH in a straight line between *her* and the *Sun*, which can never happen but at the time of FULL MOON: this eclipse begins on the MOON's *Eastern side*, and goes off on her *Western*.

5. LUNAR* ECLIPSES may be readily conceived from the annexed figure, where S is the *Sun*, E the EARTH, M the MOON, and *o* the Moon's orbit. They only happen, as before observed, at the time of *Full Moon;* because it is only then the EARTH is between the SUN and the MOON.

6. Nor do they happen every *Full Moon*, because of the obliquity of the Moon's path with respect to the Sun's; but only in such Full Moons as happen either at the intersection of those two paths, or *very near* them.

7. *Obs.* All LUNAR ECLIPSES are universal, or visible in all parts of the EARTH which have the Moon above their horizon, and are every where of the same magnitude and duration.

8. SOLAR† ECLIPSES may be understood, as to their nature or cause, by reference

* From the Latin word *Luna*, moon.
† From the Latin word *Sol*, Sun.

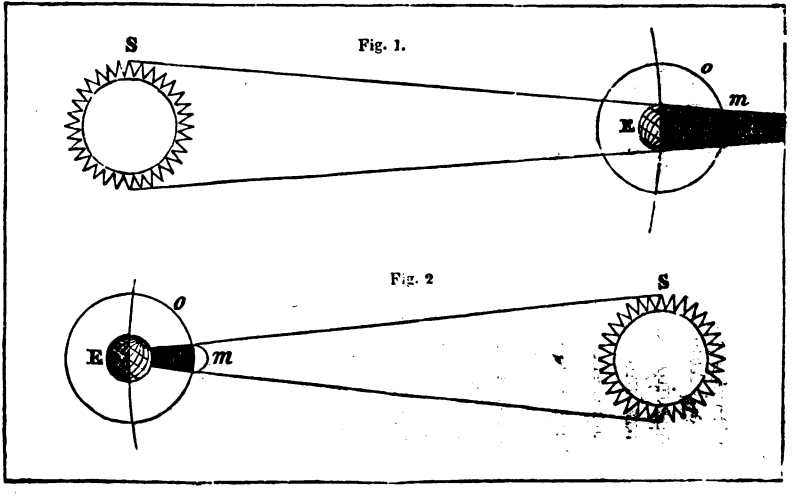


Fig. 1.
S
o
m
E
Fig. 2
o
E
m
S

to the second *figure* in the preceding page, where S is the SUN, *m* the MOON, E the Earth, and *o* the Moon's orbit; the Moon's conical shadow, travelling over a part of the Earth, makes a complete eclipse to all the inhabitants residing in that tract, and nowhere else; excepting that for a large space around it there is a fainter shade, which is called the *penumbra.**

9. *Obs.* An ECLIPSE OF THE *Sun* does not appear the same in all parts of the Earth where it is seen, but is in some *total,* while in others it is *partial.*

10. The greatest number of eclipses of both *luminaries,* which can happen in a year, is seven, and the least, two; but the most usual number is four, and it is very rare to have more than *six,* of which one half are seldom visible at all places.

11. Eclipses of the Sun are more frequent than those of the Moon, but not so many of them are visible.

12. The *longest* duration of a total and central *eclipse of the Moon,* from beginning to end, is not more than four hours, and the *shortest* not

* *Penumbra* signifies an imperfect shadow; it is compounded of two Latin words—*pene,* almost; and *umbra,* a shadow.

less than three hours and a half; and, from the motion of the Moon in her orbit, a *total eclipse of the Sun* can never exceed *four minutes.*

13. ECLIPSES are of great use in *astronomy.*

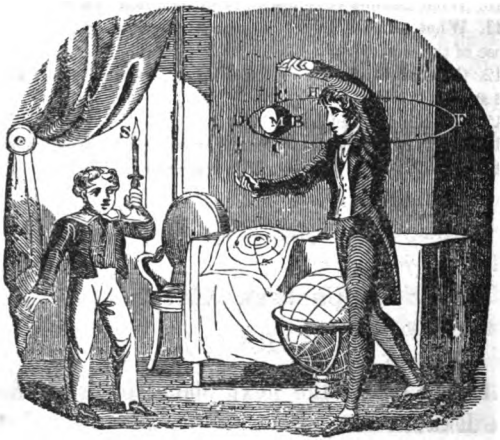
14. Eclipses of the Moon determine the *spherical figure of the Earth:* they also show that the SUN is *larger* than the EARTH, and the *Earth* than the *Moon.*

15. In *geography,* eclipses discover the *longitude* of different places; for which purpose those of the *Moon* are the more useful, because they are the more often visible.

16. The several phases and eclipses of the Moon will be more easily understood from the figure in the following page, where S is a candle, representing the Sun; B a ball, representing the Moon M; and the face of the observer the Earth.

17. If the observer carry M round his head in an orbit, he will distinguish its different phases or appearances. At C it will be in the form of a crescent; at F, full Moon; at H, half Moon; and at D, dark Moon or change.

18. If the observer's eye, the ball, and the candle be all on a level, when M is at D, S will be totally eclipsed by it from his view; and when M is at F, M will be eclipsed in the shadow of



his head: hence lunar eclipses can only happen at the time of *full* Moon; and solar ones only at the change or *new* Moon.

QUESTIONS FOR EXAMINATION.

1. What is an eclipse?
2. How were eclipses formerly beheld?
3. When is the *sun* eclipsed?
4. When is the *moon* eclipsed?

5, 6. When do *lunar* eclipses happen?

7. To what parts of the earth are lunar eclipses visible?
8. When do *solar* eclipses happen? and to whom are they visible?
9. Does a solar eclipse appear the same in all parts of the earth?

10. What number of eclipses can happen in a year?

11. What eclipses are more numerous, those of the *sun*, or those of the *moon*?

12. Of what duration is a total eclipse of the *moon*? Of what, the *sun*?

13. Are eclipses useful?

14. What do eclipses of the moon determine? What, show?

15. What do eclipses discover in geography?

CHAPTER XIII.

MARS (♂).

1. MARS is the next planet in order from the EARTH.

2. The *mean distance* of MARS from the SUN is about one hundred and forty-five millions of miles.

3. He travels through his *orbit* in little less than *two* years, at the rate of fifty-five thousand miles per hour.

4. His *diameter* is five thousand three hundred miles, which is but little more than half the diameter of the *Earth*.

5. He has a *red* and fiery appearance, which is supposed to arise from a thick atmosphere with which he is surrounded.

6. It was from his fiery or sanguinary appearance that the ancients called him MARS, who by them was considered the "*God of War.*"

7. To this planet the *Earth* and *Moon* appear like *two moons.*

8. He revolves on his axis in twenty-four hours and thirty-nine minutes.

QUESTIONS FOR EXAMINATION.

1. To what planet is Mars the next?
2. What is his mean distance from the sun?
3. How long is he travelling through his orbit?
4. What is his diameter?
5. What is his appearance?
6. Why was he called Mars?
7. Like what do the earth and moon appear to him?
8. How long is he revolving on his axis?

CHAPTER XIV.

JUPITER (♃).

1. JUPITER lies beyond the orbit of *Mars,* and is the largest of all the planets, being a thousand times larger than the EARTH.

2. His *mean distance* from the SUN is about five hundred millions of miles, and he travels at the rate of thirty thousands of miles per hour.

3. His *diameter* is about ninety-four thousand miles. He revolves on his axis in about ten hours.

4. He is attended by *four moons*, which are constantly revolving round him. The ancient poets called him the "*God of Thunder.*"

5. The swiftness of his diurnal motion is supposed to draw his atmosphere into *lines* or *streaks*, and form those appearances on his face which we call BELTS. *(See* A, *frontispiece.)*

6. Jupiter's FOUR MOONS were discovered by GALILEO in 1610, soon after the invention of the *telescope;* but the BELTS were not observed till twenty years after.

QUESTIONS FOR EXAMINATION.

1. Where does Jupiter lie? and what is his size in comparison with Mars?

2. What is his mean distance from the sun?

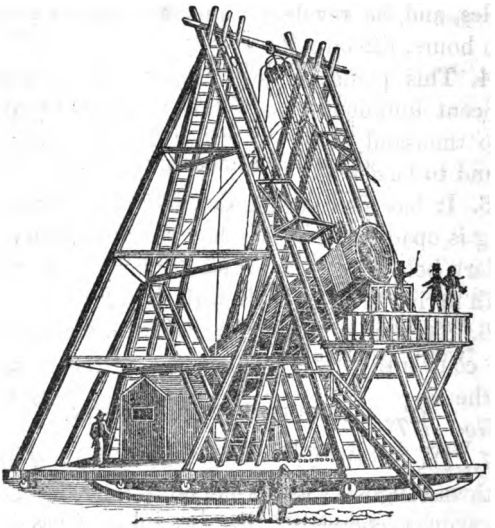
3. What is his diameter? How long is he revolving on his axis?

4. By what is he attended? What did the poets call him?

5. Into what does the swiftness of his diurnal motion seem to draw his atmosphere?

6. By whom and when were Jupiter's four moons discovered? When were the belts observed?

Chapter XV.



SATURN (♄).

1. SATURN is the next planet in order from Jupiter.

2. He moves round the Sun in about thirty years, at the *mean* distance of about nine hun-

dred millions of miles, and at the rate of twenty-two thousand miles per hour.

3. His *diameter* is about eighty thousand miles, and he revolves round his axis in about ten hours, fifteen minutes.

4. This planet is surrounded with a magnificent luminous ring, which is about twenty-two thousand miles in breadth. This ring is found to be *double.* (*See* B, *frontispiece.*)

5. It has also been discovered that Saturn's ring is opaque, for it has had the appearance of a dark belt upon the planet; which shews that both derive their light from the Sun.

6. SATURN is attended by *seven moons* which are constantly moving round him on the outside of the ring. He was called by the ancients the "*God of Time.*"

7. The sixth moon was discovered on the 28th of August, 1789; the same day that DR. HERSCHEL completed his forty feet telescope, which was the largest instrument, and possessed the highest magnifying power of any that had ever been constructed. The opposite engraving is a representation of this telescope, which he erected at *Slough*, near *Windsor.*

QUESTIONS FOR EXAMINATION.

1. Which planet is next to Jupiter?
2. How long is he moving round the sun? At what mean distance? At what rate?
3. What is his diameter? In what time does he revolve round his axis?
4. By what is he surrounded? Of what size is the ring?
5. Is it opaque?
6. By how many moons is Saturn attended? What was he called by the ancients?
7. When was the sixth moon discovered?

CHAPTER XVI.

THE GEORGIUM SIDUS (♅).

1. THE GEORGIUM SIDUS was discovered by DR. HERSCHEL, a German, in the night of March the 13th, 1781.

2. It has received the several names of the "*Georgian Planet*," the "*New Planet*," "*Uranus*," and the "*Planet Herschel*," by which last name it is called by the astronomers of all foreign nations.

3. It is about eighty times larger than the *Earth*, and moves round the *Sun* in about eighty-three years.

4. This is the remotest planet of any in the SYSTEM, and his *mean distance* from the *Sun* is nearly twice that of *Saturn's*.

5. His *diameter* is about thirty-five thousand miles, and he revolves round the *Sun* at the rate of seven thousand miles per hour.

6. The HERSCHEL is attended by *six moons*.

7. In order to make the *mean* distances of the planets clearer to the mind, they may be expressed by the following numbers: viz.

8. If *Mercury* be supposed twenty-eight miles from the *Sun*, *Venus* will be fifty-two; the *Earth*, seventy-nine; *Mars*, one hundred and nine; *Jupiter*, two hundred and seventy-three; *Saturn*, six hundred and eighty-four; and the *Georgium Sidus*, one thousand three hundred and fifty-eight miles.

9. Also the *magnitudes* of the planets, when compared with the SUN, may be better comprehended by observing the *Frontispiece;* and supposing the SUN to be two feet in *diameter*, *Mercury*, as represented by H, will then be *one-twelfth of an inch* in diameter; *Venus*, by E, *one-seventh;* the *Earth*, by D, *one-fifth;* *Mars*, by F, *one-fifteenth;* *Jupiter*, by A, *two inches* and *three quarters;* *Saturn*, by B, *two* and

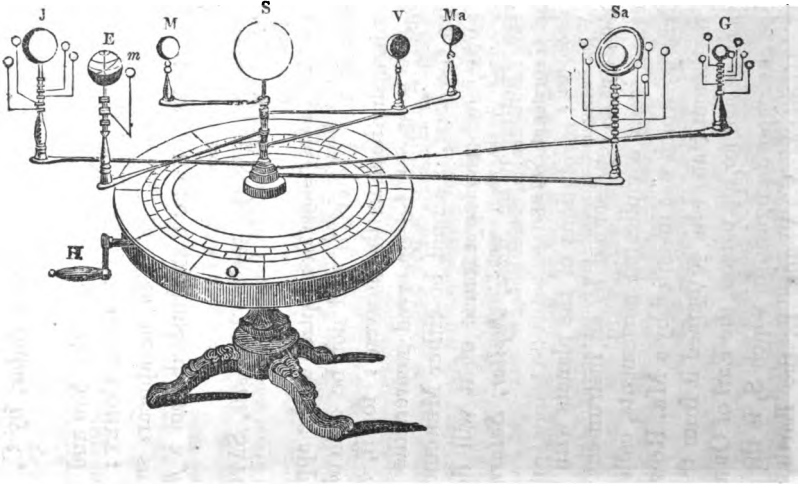
one-tenth; and the *Georgium Sidus,* by C, *one inch.*

10. When *Mars* is between the *Sun* and the *Earth,* he is often mistaken for a COMET; but when he is beyond the *Sun,* he appears small, and is scarcely to be distinguished from a *fixed star.*.

11. JUPITER is known by his *belts,* SATURN by his *ring.*

12. From this short description of the appearances of the planets, it will not be difficult to distinguish them in the heavens: for if, after sunset, a planet be observed nearer the *east* than the *west,* it cannot be either MERCURY or VENUS; and the appearance of it will determine whether it be *Mars, Jupiter, Saturn,* or the *Georgium Sidus.*

13. The revolutions of the planets with their satellites is represented by an instrument possessing many complicated movements, called an *Orrery;* which was invented by a MR. ROWLEY, a mathematician, who so named it from the respect he had for his patron, the Earl of ORRERY. See the opposite figure, in which S, is the Sun; M, Mercury; V, Venus; E, the Earth, with her Moon, *m;* Ma, Mars; J, Jupiter, with his


J
E
m
M
S
V
Ma
Sa
G
H
Q

moons; Sa, Saturn, with his belt and moons; G, Georgium Sidus, with his moons; O, the Ecliptic, or orbit of the Planets; and H, the handle, which when turned puts the Planets and their satellites in motion.

QUESTIONS FOR EXAMINATION.

1. When was the Georgium Sidus discovered?
2. What several names has it received?
3. What is its size? and how long is it moving round the sun?
4. What is his mean distance from the sun?
5. What is his diameter? and at what rate does he revolve round the sun?
6. By how many moons is Herschel attended?
7, 8. What is the mean distance from the sun of the several planets compared with each other?
9. What are their several magnitudes sun?
10. What is the appearance of Mars when between the *sun* and the *earth*? What, when beyond the sun?
11. How are Jupiter and Saturn known?
12. How are the planets distinguished in the heavens by this short description?
13. What instrument represents the revolutions of the planets and their satellites?

CHAPTER XVII.

COMETS.

1. HAVING thus, with as much clearness and perspicuity as the nature of the subject will

admit, endeavoured to describe the *planetary system*, we shall proceed to notice the COMETS, which revolve round the SUN in *orbits* extremely *eccentric*.

2. Although the COMETS revolve round the Sun in such very *oblique orbits*, their periodical times and motions are as certain and invariable as those of the planets.

3 The COMETS, like the *planets*, are solid opaque bodies, of different magnitudes, but most of those which have been observed are less than the *Moon*.

4. The number of *Comets* belonging to the SOLAR SYSTEM is unknown; but it is supposed to be very great, as the *orbits* of eighty have been already calculated.

5. They are all, however, found to move round the *Sun*, and to cross the orbits of the planets in various directions.

6. They are principally distinguished from the planets by a long transparent train or tail of light, which extends from the side that is opposite the Sun.

7. This sort of transparent tail is nothing more than a very slender vapour accompanying the *Comet*, which increases as the *Comet* ap-

proaches the *Sun*, decreases as it leaves that luminary, and then gradually disappears.

8. Comets generally appear suddenly; and after being visible for a few days or weeks, again pursue their devious course through immense fields of *ether*, in regions very far beyond the limits of our system.

9. These *heterogeneous* bodies are commonly distinguished into three kinds; viz., *bearded*, *tailed*, and *hairy*; though, in fact, this division relates rather to the several situations of the *same Comet*, than to the *phenomena of several*.

10. When the COMET is *eastward* of the SUN, and recedes from it, the light before it occasions the appearance of a *beard*: when it is to the *west* of the SUN, and is approaching him, it exhibits the appearance of a *tail*.

11. But when the COMET and the SUN are diametrically opposite, (the EARTH intervening), the *train* is hidden behind the *body* of the COMET, excepting a little that appears on its verge, resembling a border of *hair*.

12. Comets were imagined in ancient times to be prodigies hung out by the immediate hand of God in the heavens, and intended to alarm the world.

13. Their nature being now better understood, they are no longer terrible to the generality of people.

14. The paths which they describe, and the laws to which they are subject, have been explained by NEWTON, HERSCHEL, HAMILTON, and others.

15. Their revolutions are governed throughout by the same law, of describing *equal areas* in *equal times*, which is known to regulate the motions of all the other bodies in the "SYSTEM."

16. *Obs.* The *Comet's tail* is always on that side of the Comet which is from the Sun; and from this alone does it derive its name; *coma* being a Greek word signifying *hair*, and hence *comet.*

17. Comets are a part of astronomy about which but little is known; yet enough for mankind to be aware, that they are in general inconsiderable, and can produce no material effect upon our earth, or the solar system.

EXPLANATORY REMARKS.

1. EXCENTRIC, also ECCENTRIC, means departing or deviating from a centre; not having the same centre with another circle: *figuratively*, it signifies not answering the same design or end intended; irregular; not consistent with any rule or established custom.

8. ETHER is a thin kind of matter finer and rarer than *air*, commencing from the limits of our atmosphere, and expanded through all regions of space.

9. HETEROGENEOUS signifies contrary, dissimilar, or different in properties or nature.

11. DIAMETRICALLY is according to the direction of a diameter; in direct opposition.

12. PRODIGIES are things out of the common course of nature; things which astonish by their greatness or novelty.

14. AREAS are the surfaces contained between any lines or limits: in *geometry*, they are the spaces contained within the lines bounding them, reckoned in the square of any measure.

QUESTIONS FOR EXAMINATION.

1. How do the comets revolve round the Sun?
2. What is remarked of their periodical times and motions?
3. What are comets? What are their sizes?
4. What is their number?
5. What are the motions all comets are found to have?
6. How are they principally distinguished from the planets?
7. What is this sort of transparent tail?
8. When, and how long do comets appear?
9. Into what are these heterogeneous bodies vulgarly distinguished?

10, 11. When do these several distinctions appear?

12. What were comets imagined by the ancients?

13. How are they now understood?

14. What has Newton and others explained of them?

15. By what are their revolutions governed?

16. Where is the comet's tail situated? Whence is the name derived?

17. Is this *part* of *astronomy* much known?

CHAPTER XVIII.

OF THE POINTS OF THE COMPASS.

1. THE situation of the different places and countries in the world is always considered with regard to the *four Cardinal Points;* viz. *north, east, west,* and *south.*

2. So that some are *oriental,* or towards the EAST, with regard to others that are *occidental,* or towards the WEST.

3. Thus, IRELAND is to the *west* of England, GERMANY on its *east;* AFRICA is to the *south* of EUROPE, and RUSSIA to the *north* of TURKEY.

4. The COMPASS is that instrument which is used at sea by *mariners:* hence it is more usually called the "MARINERS' COMPASS."

5. The invention of this instrument is commonly ascribed to FLAVIO of *Malphi,* in Italy, about the year 1302.

6. The *Mariners' Compass* consists of a circular box, which contains a paper card, on which is drawn the thirty-two *points of the Compass;* and this card is fixed on a magnetic needle, which always turns to the north, except a small

deviation which is variable at different places, and at the same place at different times.

7. All places that lie between the cardinal points are described according to their bearing. Thus,

8. If the place be nearer to the *south point* than to the *east point*, it is said to lie *south-east* by *south;* but if it be nearer to the *east* than to the *south*, it is said to lie *south-east* by *east;* and so on of others.

9. If the place lie directly between the cardinal points, it is described thus—*north-east, north-west, south-east, south-west;* but when it approaches nearer to one point than to the other, it is expressed as before mentioned.

EXPLANATORY REMARKS.

1. CARDINAL means principal, chief, supreme. Thus *cardinal winds* are those that blow from the four corners of the compass: *cardinal signs* in the Zodiac are *Aries*, the ram, *Libra*, the scales, *Cancer*, the crab, and *Capricornus*, the goat. In arithmetic, *cardinal numbers* are such as express positively how many things there are; as, 1, 2, 3, 10, &c. In morality, the *cardinal virtues* are justice, prudence, temperance, and fortitude. As a substantive, it means an eminent dignitary in the church of Rome, who has a voice in the *conclave* at the election of a Pope. *Conclave* is a private or inner apartment, the place wherein the election is held for a Pope: it also means the assembly of *cardinals* itself.

2. ORIENTAL means eastern, from the Latin *oriens*, the east. OCCIDENTAL means western, from *occidens*, the west.

QUESTIONS FOR EXAMINATION.

1. With regard to what is the situation of the different places in the world considered?

2, 3. Give examples.

4. What is the compass? What, more usually called?

5. To whom is the invention of this instrument ascribed?

6. Of what does the mariners' compass consist? Where does the magnetic needle always turn?

7, 8, 9. How are places described that lie between the cardinal points?

CHAPTER XIX.

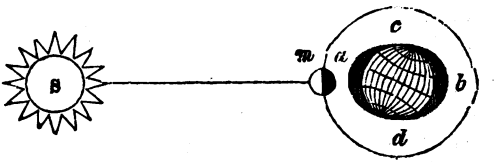
THE TIDES.

1. THE Tides are two periodical motions of the sea; called also the *flux* and *reflux*, or the *ebb* and *flow*.

2. When the motion of the water is against the wind, it is called a *windward tide;* when *wind* and *tide* go the same way, *leeward tide;* when it runs very strong it is called a *tide-gate*.

3. The TIDES are caused by the attraction of the SUN and MOON; as exemplified by the following engraving, in which the Sun S and the

Moon *m* heap up the waters at *a* and *b* of the Earth, and in consequence depress them at the intermediate points *c d.*



4. The MOON has the greatest power of attraction, because she is so much nearer the EARTH.

5. *Fluids* are more susceptible of impression than *solids;* hence attraction sensibly affects them.

6. As the Earth revolves round her axis, portions of her surface successively pass under the moon and create the *Tides,* which happen about twelve hours and three quarters apart.

7. The MOON has the greatest influence when on the *meridian;* yet the *tides* happen not till about three hours after the MOON has passed the meridian.

8. This is owing to that universal property of matter, by which it would continue in the same

state, unless affected by some cause. So the waters flow to the particular spot of attraction, where they continue rising, till the moon overcomes the impulse, and draws them to some other spot.

9. The sea is observed to flow for certain hours, *from* the SOUTH *towards* the NORTH, in which *motion* or *flux*, which lasts about *six hours*, the sea gradually swells; so that entering mouths of rivers, it drives back the river waters to their heads.

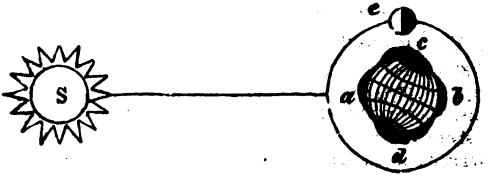
10. After a continual *flux*, or flowing of *six hours*, the SEA seems to rest for a quarter of an hour, and then begins to ebb, or retire back again, from *north* to *south*, for six hours more; in which time, the waters sinking, the rivers resume their natural course.

11. After a seeming pause of a quarter of an hour, the sea again begins to flow as before; and thus it has alternately *risen* and *fallen* in the space of twelve hours and fifty minutes, which is the *length* of a *lunar day*.

12. *Obs.* This wonderful appearance of the *ebb* and *flow* of the OCEAN is successfully explained from SIR ISAAC NEWTON'S universal principles of gravity and attraction.

13. The TIDES are *greater* than ordinary *twice* every month, that is, about the times of *new* and *full moons;* these are called SPRING TIDES. See *a b* in the above engraving.

14. The TIDES are *less* than ordinary *twice* every month, that is, about the *first* and *last* quarters of the Moon; and these are called NEAP TIDES. See *a b* in the following figure.



15. Because in *these quarters* of the MOON the SUN at S raises the water at *a* and *b* where the *Moon* at *e* depresses it, and depresses it at *c* and *d* where the *Moon* at *e* raises it; so that the *Tides* are made by the difference only of their actions.

16. There are scarcely any *Tides* perceptible in the *Mediterranean* or *Baltic Seas.*

17. Those places have the greatest Tides

which are in the *Torrid Zone* between the *Tropics*.

18. The greatest known TIDE is at the mouth of the river INDUS, where the water rises thirty-six feet in height.

19. The TIDES are also remarkably high on the coasts of *Malay*, in the *Straits* of *Sunda*, in the *Red Sea*, along the coasts of *China* and *Japan*, at *Panama*, and in the *Gulf of Bengal*.

EXPLANATORY REMARKS.

1. FLUX means the act of flowing; the state of passing away and giving place to others. In *hydrography*, it means a regular periodical motion of the sea, happening twice in twenty-four hours, whereby the water is raised, and driven violently against the shore.

REFLUX is the act of flowing back; the backward course of water.

QUESTIONS FOR EXAMINATION.

1. What are tides?
2. When the motion of the water is against the wind, what is it called? When with the wind, what? When together, and very strong, what is it called?
3. How are the tides caused?
4. Which luminary has the greatest power of attraction?
5. Which are more susceptible of impression, *fluids* or *solids*?
6. When do the tides happen?
7. When has the moon the greatest influence? When do the tides happen in regard to the moon?
8. To what is this owing?

9, 10, 11. How is the sea observed to flow?
12. By whom are the tides successfully explained?
13. When are the tides greater than ordinary?
14. When are they less than ordinary?
15. Why?
16. Where are there scarcely any tides perceptible?
17. Which places have the greatest tides?
18. Where is the greatest known tide?
19. Where are the tides also remarkably high?

Chapter XX.

OF WHIRLPOOLS.

1. When a regular current is opposed by another in a narrow strait, or where the bottom of the sea is very uneven, a WHIRLPOOL is often formed.

2. The most dreadful and voracious is that called the MAELSTROOM, upon the coast of Norway.

3. The name it has received from the natives signifies the *Navel of the Sea*, since they suppose that a great share of the water of the sea is sucked up and discharged by its vortex.

4. The body of the waters that form this

whirlpool is extended in a circle above thirteen miles in circumference.

5. In the middle stands a rock, against which the *Tide*, in its *ebb*, is dashed with inconceivable fury.

6. This whirlpool instantly swallows up all that comes within the sphere of its violence, *trees*, *timber*, and *shipping*; and in *six hours* disgorges them all again with the same violence with which they are drawn in.

7. The noise of this dreadful *vortex* still farther contributes to increase its terror, which, with the dashing of the waters, and the dreadful *valley*, if it may be so called, caused by their circulation, makes one of the most tremendous objects in nature.

EXPLANATORY REMARKS.

3. VORTEX, a Latin word, is any thing that is whirled round: an eddy, a whirlpool.

6. DISGORGES means vomits or discharges from the mouth: *figuratively*, to discharge or pour out with violence.

QUESTIONS FOR EXAMINATION

1. How is a whirlpool formed?
2. Which is the most dreadful and voracious whirlpool?
3. What is the signification of the name given it by the natives?

4. To what distance is this body of water extended?
5. What stands in the middle of the whirlpool?
6. What does this whirlpool swallow and again disgorge?
7. What contributes to increase its terror?

Chapter XXI.

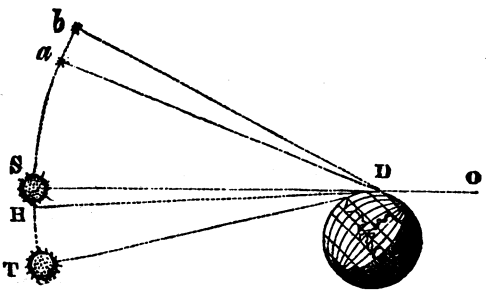
OF THE ATMOSPHERE, OR AIR, AND WINDS.

1. ATMOSPHERE is the AIR, and WIND is the AIR put in motion, which is caused by the rarefying beams of the Sun.

2. The Atmosphere partakes of all the motions of the Earth, both *annual* and *diurnal;* and from its density, a ray of light passing obliquely through it from the sun, moon, or stars, is bent out of a straight course, and hence said to be *refracted.*

3. This *refraction,* therefore, makes a heavenly body appear to be higher above the horizon than it really is. Thus, in the following figure let H O be the sensible horizon to a person at D; when a star is at *a,* it will, on account of refraction, appear to a person at D, to be at *b;* so

when tne sun is actually below the horizon at T, and consequently not risen, it appears above the horizon at S; this occurs about three minutes before he rises, and about the same time after he sets.



4. WINDS are named from the points of the compass from which they come; as, a *north wind*, an *east wind*, a *south* or *west wind*.

5. From their continuance they are either *constant*, *periodical*, or *variable*.

6. *Constant winds* are such as blow the same way for some particular period of time, and *variable winds* are those which shift frequently without any uniform action.

7. PARTICULAR WINDS are those which blow

sometimes from one point of the *compass*, and sometimes from *another*, indifferently.

8. PERIODICAL WINDS are the *Monsoons*, which, in the *Indian Ocean*, blow *six months* in one direction, and *six months* in the opposite.

9. The *constant*, or *general trade wind*, is in the *Atlantic* and *Pacific Oceans*, blowing constantly to the extent of about thirty degrees, from the *north-east*, on the *north side* of the EQUATOR, from the *south-east* on the *south side* of the EQUATOR, and *east* on the *equator* itself.

10. The *variable winds*, found beyond thirty degrees *north* and *south* of the equator, blow from all points of the compass, and are subjected to no precise period either in duration or return.

11. Winds are also denominated according to the *velocity* or *slowness* of their motion: a *gentle wind* is called a BREEZE, a *moderate wind*, a GALE, and a very *hard wind*, a STORM or HURRICANE.

12. The *velocity* of wind, in a gale, does not exceed *fifteen miles* an hour; but in *storms* and *hurricanes*, it is sometimes more than *sixty*.

13. The phenomenon of the *trade wind* is occasioned by the action of the Sun, which, in moving from *east* to *west* rarefies and expands

the air immediately under him; so that a *stream* or *tide* of AIR always attends him in his course, occasioning an invariable *east wind* within these limits.

14. This general cause, however, is modified by various particulars, which are of too complicated a nature to be fully discussed in so small a work as this.

15. *Obs.* In the space of *six weeks*, by the assistance of the *trade wind*, SHIPS are known to cross an immense ocean, that takes more than as many months to return.

16. Upon returning, the *trade wind*, which has been so propitious, is then avoided; the mariner is obliged to steer in *northern*, or *southern latitudes*, and to take the advantage of every casual wind that offers to assist him into *port*.

17. Were the whole surface of the globe an ocean, there would probably be but this *one wind*, for ever blowing *from the east*, and pursuing the motion of the SUN *westward*.

18. All the other winds seem subordinate to this; and many of them arise from the deviations of its current, which are caused by the mountains and other irregularities of the *land*.

QUESTIONS FOR EXAMINATION.

1. What is the atmosphere? What, wind?

2. Of what does the atmosphere partake? What does its density cause?

3. What does this refraction make the heavenly bodies appear to be?

4. How are winds named?

5. How are they named from their continuance?

6. What are *constant* winds? What, *variable*?

7. What, *particular*?

8. What, *periodical*?

9. What, the *constant* or *general* trade wind? And where does it obtain?

10. Whence do the variable winds blow, that are found beyond thirty degrees north and south of the equator?

11. What are winds also denominated?

12. What is the velocity of wind in a gale? In a storm, or hurricane?

13. How is the phenomenon of the trade wind occasioned?

14. By what is this general cause modified?

15. *Obs.* In how short a time do ships cross the ocean by the aid of the trade winds?

16. What winds do they avoid, and what, seek, on returning?

17. What probably would be the only wind were the whole surface of the globe an ocean?

18. What do the other winds seem? And from what do many of them arise?

CHAPTER XXII.

OF EARTHQUAKES AND VOLCANOES.

1. EARTHQUAKES and VOLCANOES are both produced from the same cause.

2. Those countries that yield great stores of *sulphur* and *nitre* are by far the most injured by EARTHQUAKES.

3. *Burning Mountains* and *Volcanoes* are caused from the inflammable substances which are confined and take fire in the bowels of the EARTH.

4. VOLCANOES constitute, without doubt, some of the most striking and formidable phenomena which nature has presented to our view.

5. They are not, however, so destructive to the lives of the human race as EARTHQUAKES; but they offer to the eye something much more terrific.

6. Their number is very considerable, nearly two hundred having been reckoned by different writers.

7. There is an immense range of them running from north to south on the continent of

America, and occupying the *summits* of many of the ANDES, as well as of the *ridges* in *Mexico* and *California*.

8. There is also a considerable number which spread along the *eastern coast* of Asia, and sprinkle the *Indian islands*.

9. *Iceland*, an island in the North Sea, and north of Great Britain, alone contains *eight* volcanoes.

10. One of the loftiest in the world is the *Peak of Teneriffe*, though at present less frequent in its eruptions than many others.

11. The two volcanoes with which we are best acquainted are those of ETNA and VESUVIUS.

12. ETNA has been burning as far back as the records of European history extend.

13. We have an account of an eruption during the EXPEDITION of the ARGONAUTS, which took place at least twelve centuries before the commencement of the *Christian era*.

14. The greatest *Earthquake* described in history is that which happened in the year 1693; the damages of which were felt in *Sicily*, and its motions in *Germany*, *France*, and *England*.

15. It extended to a circumference of *several thousand miles*; chiefly affecting the *sea coasts*

and great rivers; and was more perceivable upon the mountains than in the valleys.

16. Its motion were so rapid, that those who lay at their length were tossed from side to side, as upon a rolling billow.

17. The walls were dashed from their foundations; and a great number of towns and villages were either destroyed or greatly damaged.

18. The city of CATANEA, in particular, was entirely overthrown.

19. A traveller, who was on his way thither, at the distance of some miles, perceived "a black cloud, like night, hanging over the place.

20. "The sea all of a sudden began to roar; MOUNT ETNA to send forth great spires of flame; and soon after a shock ensued, with a noise as if all the artillery in the world had been at once discharged."

21. Our traveller, being obliged to alight instantly, felt himself raised a foot from the ground; and turning his eyes to the city, he, with amazement, saw nothing but a thick cloud of dust in the air.

22. The *birds* flew about astonished; the SUN was darkened; the beasts ran howling from the hills; and, although the shock did not continue

above three minutes, yet nearly nineteen thousand of the inhabitants of SICILY perished.

23. CATANEA, to which city the describer was travelling, seemed the principal scene of ruin; its place was not to be found; and not a footstep of its former magnificence was to be seen remaining.

QUESTIONS FOR EXAMINATION.

1. From what are earthquakes and volcanoes produced?
2. What countries are the most injured by earthquakes?
3. From what are burning mountains and volcanoes caused?
4. What sort of phenomena do volcanoes constitute?
5. Are volcanoes as destructive as earthquakes?
6. What is the number of volcanoes?
7. Where is there an immense range of them?
8. Where is there also a considerable number of them?
9. How many does Iceland contain?
10. Which is one of the loftiest in the world?
11. What are the two volcanoes with which we are best acquainted?
12. How far back has Etna been burning?
13. What is the earliest account we have of an eruption?
14. Which is the greatest earthquake described in history?
15. How far did it extend?
16, 17. What was the rapidity of its motion? and its effects?
18. What happened to the city of Catanea?
19, 20. What did a traveller perceive on his way thither?
21. Describe what the traveller felt; and what he saw.
22. How did it affect the birds and beasts? What number of inhabitants perished?
23. What city was the principal scene of ruin?

CHAPTER XXIII.

OF MATTER AND MOTION.

1. MATTER is a term in philosophy, signifying whatever is extended and capable of making resistance; hence, all bodies, whether SOLID or FLUID, that are *extended*, and *resist*, are *material*, or made up of MATTER.

2. MOTION is the act of changing place; or it is that affection of matter by which it passes from one point of *space* to *another*.

3. MATTER is of itself inactive, and indifferent to *rest* or *motion*.

4. A body at *rest* will continue so for ever, unless it be put in *motion* by some external cause; and a body in *motion* will move for ever, unless stopped by some external cause.

5. It is its friction against the ground, and the resistance it meets with from the air in its course, as well as the *gravity* and *attraction* between the body and the *Earth*, that cause its *restive* quality.

6. *Obs.* It is by *gravity* or *attraction* that the SEA is kept in its channel, and it is by the same cause the various bodies which cover the surface

of the *Earth* are kept from flying off into the air: it is this that retains the PLANETS in their *Orbits*, and preserves the whole fabric of nature from confusion and disorder.

7. All *motion* is naturally rectilineal;* that is, which is performed in *straight lines*.

8. A *bullet* thrown by the *hand*, or discharged from a *cannon*, would continue to move in the same direction it received at first, if no other power directed its course.

9. Therefore, when we see a body moving in a curve, of whatever kind, we conclude it must be acted upon by two powers at least; one to put it in *motion*, and another drawing it off from the *rectilineal* course which it would otherwise have continued to move in.

10. GRAVITY, or ATTRACTION, is that universal disposition of matter, which inclines, or carries, the *lesser part* towards the *centre* of the *greater part;* which is called WEIGHT, or GRAVITATION, in the *lesser body;* but ATTRACTION in the *greater*, because it draws, or attracts, as it were, the lesser body to it.†

11. Thus all bodies, on or near the Earth's

* From the Latin *rectus*, right or straight; and *linea*, a line.

† See "Pinnock's Second Step to Knowledge."

surface, have a tendency, or seeming inclination, towards its centre; and but for this principle in nature, the EARTH (considering its form and situation in the universe) could not subsist as it is.

12. *Obs.* SIR ISAAC NEWTON is very justly considered as the author of the "*Theory of universal Gravitation.*"

13. The *laws of motion*, as delivered by NEWTON in his "*Principia,*" and on which he has supported the whole system of his philosophy, are the three following:

14. First, Every body perseveres in its state of *rest* or *uniform motion* in a *right line*, until a *change* is effected by *the agency* of some *external force.*

15. Second, Any change effected in the quiescence or motion of a body is in the direction of the force impressed, and is proportional to it in quantity.

16. Third, *Action* and *reaction* are equal and in contrary directions.

QUESTIONS FOR EXAMINATION.

1. What is matter?
2. What is motion?
3. What is matter itself?
4. Will a body continue in rest or motion?

5. What causes its restive quality?

6. *Obs.* What is the effect of *gravity* or *attraction*?

7. What is the natural direction of motion?

8. In what direction does a bullet continue to move?

9. What conclusion do we draw from a body moving in a curve?

10. What is *gravity* or *attraction*?

11. Towards what have all bodies in or near the earth's surface a tendency?

12. What is Sir Isaac Newton justly considered?

13, 14, 15, 16. What are the *laws of motion* delivered by NEWTON in his *Principia*?

CHAPTER XXIV.

OF THE VARIOUS KINDS OF MOTION.

1. MOTION is of various kinds, as follows:

2. ANGULAR MOTION, is the motion of a body as referred to a centre, about which it revolves: such is the motion of the planets.

3. COMPOUND MOTION is that which is produced by two or more powers acting in different directions.

4. EQUABLE or UNIFORM MOTION is when the body moves continually with the same velocity, passing over *equal spaces* in *equal times*.

5. ACCELERATED MOTION is that which is

continually receiving constant accessions of velocity.

6. RETARDED MOTION is that which suffers continual diminution of velocity, the laws of which are the reverse of those for *accelerated motion.*

7. NATURAL MOTION is that which is natural to bodies, or that which arises from *gravity.*

8. PROJECTILE MOTION is that which is not natural, but impressed by some external cause; as, when a *stone* is thrown from a *sling*, an *arrow* from a *bow*, or a *ball* from a *gun.*

9. RECTILINEAR MOTION is that which is performed in *right lines.*

10. ROTATORY MOTION is the motion of the different parts of a solid body about an *axis*, called the "*axis of rotation*," being thus distinguished from the *progressive motion* of a body about some distant point or centre.

11. Thus, the *diurnal motion* of the EARTH is a MOTION of ROTATION, but its *annual motion* one of REVOLUTION.

EXPLANATORY REMARKS.

4. EQUABLE, from the Latin *æqualis*, equal, means even; alike; consistent with itself; uniform in respect to form, motion, &c.

5. ACCELERATED means hastened, quickened.
6. RETARDED signifies to hinder in motion or swiftness.
8. PROJECTILE means impelled forward.
10. ROTATORY denotes whirling round, as a wheel.

QUESTIONS FOR EXAMINATION.

1. Are there more kinds of motion than one?
2. What is *angular* motion?
3. What is *compound* motion?
4. What, *equable* or *uniform* motion?
5. What, *accelerated* motion?
6. What, *retarded* motion?
7. What, *natural* motion?
8. What, *projectile* motion?
9. What, *rectilinear* motion?
10. What, *rotatory* motion?
11. What are the motions of the earth?

CHAPTER XXV.

PROOF OF THE EARTH'S BEING ROUND, GLOBULAR, OR SPHERICAL.

1. THAT the EARTH is *round* is fully proved from an *eclipse* of the *moon;* for the obscured part of the moon, caused by the *conical* shadow of the EARTH, being always bounded by a cir-

cular line, the earth itself, for that reason, must be *round*, or *spherical*.

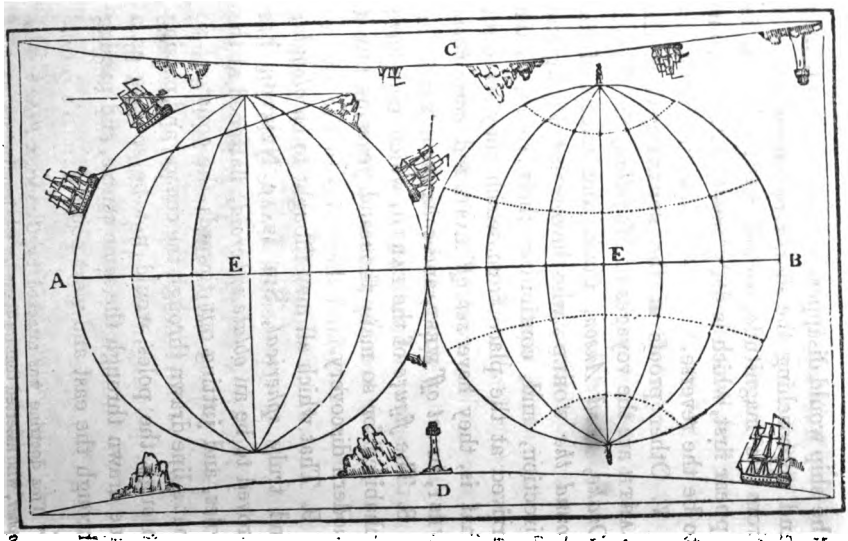
2. The ROUNDNESS of the EARTH is also demonstrated from the appearance of the *sea*, and the observations of persons standing upon the shore, and viewing a ship departing from the port.

3. They first lose sight of the bottom of the vessel, whilst they can still see the rigging and the flags at the tops of the masts; but, as the ship recedes farther, they lose sight of these also, as if the whole were sunk into the ocean.

4. The same appearances happen, but in an inverted order, when a ship comes into port; the first thing seen is the top of the mast, and as she approaches land she seems to rise by degrees out of the water, till the whole ship is visible; as is represented by A B in the following engraving.

5. Also, when a *ship* sails towards the land, the *mariners* first descry the tops of *steeples*, *trees*, &c. pointing above the water; next they behold the buildings; and lastly the shore; which can only be caused by the EARTH's *rotundity*. (*See following engrving, p.* 96. *figures* C D.)

6. For if the sea were a plane, every part of


C
A
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D

the ship would disappear at once, both at leaving and approaching the shore; or rather the *hull*, from its magnitude, would disappear last, or appear first, which is daily proved by experience to be the reverse.

7. Other proofs of the SPHERICITY of the EARTH are the voyages of *Magellan, Sir Francis Drake, Lord Anson, Cook*, and many others, *round the* WORLD; who having set off in one direction, and continuing their course, have arrived at the place from which they set out; that is, they have *set off* EAST, and *come home* WEST, or *set off* WEST, and *come home* EAST.

8. The *figure* of the EARTH, which men have inhabited for so many thousand years, is but a modern discovery.

9. That which all men thought to be *globular* and truly *spherical*, SIR ISAAC NEWTON has proved to be an *oblate spheroid*, flattened at the poles, and jutting out towards the equator; so that a line drawn through the centre, and passing through the poles, would not be so long as a line drawn through the same centre, and passing through the east and west points.*

* This doctrine was attacked by CASSINI, a *French philosopher*, who asserted that its diameter was lengthened towards the

10. This figure may be easily understood by fixing a ball of soft clay on a spindle, and whirling it round; for we shall find that it will jut out or project towards the middle, and flatten towards the poles.

11. The difference between this *form* and that of a *globular* or *spherical figure* is so small, that it may be represented by a *globe* without any sensible error. (*See figure, Chap.* III.)

12. By whom the *roundness* of the EARTH was discovered is unknown.

13. The earliest period mentioned in history is at the taking of BABYLON by *Alexander the Great;* when it was discovered that ECLIPSES had been calculated for many centuries before the birth of CHRIST.

14. These calculations evidently imply a previous knowledge of the *sphericity* of the EARTH.

poles. To determine this dispute, the King of France, in 1736, sent out some able mathematicians towards the NORTH POLE, and to the EQUATOR, to measure a degree, or the three hundred and sixtieth part of a *great circle;* and from their report, the theory or *hypothesis** of *Sir Isaac Newton* was confirmed beyond dispute.

* Hypothesis signifies a system formed on some principle not used, and laid down from the imagination, to account for some phenomena.

15. This form must also have been known to THALES, the *Milesian*, who, about five hundred and eighty years before Christ, foretold an *Eclipse of the Sun.*

EXPLANATORY REMARKS.

1. CONICAL signifies having the form of a cone, sugar-loaf, or pyramid.

4. INVERTED, turned upside down, placed in a method or order contrary to that which was before.

6. PLANE means a level surface: it is also an instrument used in smoothing or levelling boards.

HULL is the body of a ship.

7. SPHERICITY means roundness: *sphere* signifies a globe or ball, and *spherical* round, globular.

9. OBLATE denotes flattened at the poles; it is usually applied to a *spheroid.*

SPHEROID is a solid approaching to the shape and figure of a sphere.

QUESTIONS FOR EXAMINATION.

1. How is the earth fully proved to be round?
2. How is the roundness of the earth otherwise demonstrated?
3. Describe the appearance of a ship departing from port.
4. Describe the appearance of a ship coming into port.
5. Describe the observations of mariners sailing towards the land.
6. What would be the appearance were the sea a plane?
7. What are other proofs of the sphericity of the earth?
8. How long has the figure of the earth been discovered?
9. Of what shape has Sir Isaac Newton proved it to be?
10. How may this figure be easily understood?
11. How may the figure of the earth be represented?

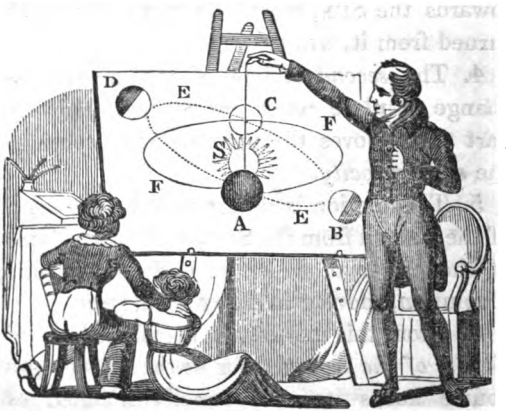
12. By whom was the roundness of the earth discovered?

13. What is the earliest period mentioned in history of an eclipse?

14. What do these calculations evidently imply?

15. To whom must this form also have been known?

CHAPTER XXVI.



OF THE MOTIONS OF THE EARTH.

1. THE *velocity* of the EARTH round its axis is not equal, differing according to the distance from the *Equator*.

2. It is swiftest at the equator on account of

passing through a *greater space;* whence its rapidity gradually decreases towards the poles, in consequence of passing through less space, but in the same time.

3. From this revolution of the EARTH upon its *axis* arises the *difference* of DAY and NIGHT; for in those parts of the EARTH that are turned towards the SUN, it will be DAY; and in those turned from it, NIGHT.

4. The *second motion* of the EARTH is its change of place *round the* SUN, whereby every part of it moves through the *same space,* with the *same velocity.*

5. This motion is determined by the distance of the EARTH from the SUN, or the *semi-diameter* of the ORBIT in which it performs its annual revolution, moving in a day *one degree.*

6. From this motion are occasioned the *vicissitudes of the seasons;* for as the EARTH in this course keeps its *axis* equally inclined every where to the *plane of the Ecliptic,* and *parallel to itself,* and as the *plane of the Ecliptic* inclines twenty-three degrees and one half towards the *Equator,* the EARTH in this direction has sometimes one of its poles nearest the SUN, and sometimes the other.

7. Hence are *heat* and *cold*, *summer* and *winter*, and LENGTHS of *days* and *nights*

8. If, as in the above engraving, two hoops be fixed in the direction of E and F, and a candle placed at S, we may, by suspending a ball at A, twirled round by a thread, and moving it along the hoop E, be entertained with a miniature representation of all the changes of day and night, and the varied seasons, as shown by the rays of the candle shining on the ball.

QUESTIONS FOR EXAMINATION.

1. Is the velocity of the earth round its axis equal?
2. Where is it swiftest?
3. What arises from this revolution of the earth round its axis?
4. What is the second motion of the earth?
5. How is this motion determined?
6. What are occasioned from this motion?
7. What are hence produced from the earth's two motions?

CHAPTER XXVII.

OF METEORS.

1. THE term METEOR is used to denote all the various *phenomena* of the *atmosphere*, which

are formed out of the common elements by the action of the heavenly bodies.

2. METEORS are divided into *igneous* or *fiery*, *aërial* or *airy*, *aqueous* or *watery*.

3. IGNEOUS METEORS consist of sulphureous smoke set on fire; such are *lightning*, *thunder*, *falling stars*, &c.

4. AERIAL METEORS consist of air and spirituous exhalations; such are *winds*, &c.

5. *Obs.* Spirituous exhalations signify a kind of fume, consisting of dry heated particles exhaled or drawn forth from the earth by the heat of the Sun.

6. AQUEOUS METEORS are composed of *vapours* or *watery particles*, condensed by cold or heat; such are *clouds*, *rainbows*, *hail*, *snow*, &c.

7. Some authors, however, apply the term Meteor exclusively to denote those luminous bodies which appear at a considerable height above the earth, which are usually called *falling stars*.

8. When these fiery collections are formed near the *earth*, they are sometimes heard to explode with great violence, as in the case of those which appear in the time of thunder.

9. According to the opinion of Dr. Blagdon,

these meteors are great bodies of *electric matter*,* moving from one part of the heavens, where we suppose it is superabundant, to another where it is deficient.

QUESTIONS FOR EXAMINATION.

1. What is meant by the term meteor?
2. Into what are meteors divided?
3. Of what do *igneous* meteors consist?
4. Of what do *aërial* meteors consist?
5. What do *spirituous* exhalations signify?
6. Of what are *aqueous* meteors composed?
7. To what do some authors exclusively apply the word meteor?
8. When are these fiery collections heard to explode?
9. Of what are they composed, in the opinion of Dr. Blagdon?

CHAPTER XXVIII.

OF THE FORMATION OF CLOUDS, SNOW, RAIN, HAIL, &c.

1. A CLOUD is a collection of *vapours* in the air, drawn from the *sea*, or *damps* of the EARTH, by the *heat* of the SUN

* Electric matter is a fine rare fluid, supposed to issue from electrical bodies. The first body in which this property was discovered, and the only one in which it was supposed to reside, was *amber*; but it is now known to be contained in a variety of bodies, such as metals, charcoal, water, wax, silk, &c.

2. "They consist of very small drops of water suspended in the air; for a *cloud* is nothing but a *mist* flying high in the air, as a *mist* is nothing but a *cloud* here below."—*Locke.*

3. CLOUDS are the greatest and most considerable of all *meteors*, as furnishing water and nourishment to the EARTH.

4. *Clouds*, *rain*, *hail*, and *snow*, are caused by the reflected rays of the Sun from the particles of vapour evaporated from the surface of the water.

5. These particles continue to ascend till they rise above the *operation* of the reflected rays, which *reaches* but to a certain height above the surface of the EARTH.

6. When arrived at this region, which is cold for want of reflected heat, they will be condensed, and suspended in the form of clouds.

7. Some vapours that ascend to great heights will be frozen into snow; others, that are *condensed* lower down, will put on the appearance of a mist, of which the clouds themselves are formed.

8. These clouds, being blown about by winds, become too weighty for the air to sustain them, and will descend either in *snow* or *rain*.

9. Mists are formed from that part of vapour exhaled by the Sun, which, at his departure, beginning to collect together, become heavier than air, and fall back in *dews*, which differ only from rain in descending before they have had time to condense into a visible form.

10. HAIL is caused from the fluid particles descending through the cold regions of the air, when the drops of rain are congealed into ice. *Hail* is most frequent in summer.

11. *Obs.* The reason that hail is so frequent in summer is, that during the summer season, greater quantities of *nitre* are exhaled from the Earth than at any other period of the year.

12. NITRE is that salt, which we know under the name of *nitre*, or *saltpetre*; and nitrous *particles*, when they ascend into the air, are known greatly to contribute to freezing.

13. THUNDER is produced from the collision of two clouds loaded with igneous particles; and LIGHTNING is an electrical flash produced by their immediate contact.

14. All clouds contain a very considerable portion of *electric fluid*,* and in numerous

* See note, p. 102.

instances, when they have become very highly electrified, many very terrible and destructive phenomena have been occasioned by them.

15. The most extraordinary instance of this kind, perhaps, on record, happened in the island of JAVA, in the *East Indies*, in August, 1772.

16. On the 11th of that month, at midnight, a bright cloud was observed covering a high mountain in the district called *Cheribon*, and at the same time, several reports were heard like those of a gun.

17. The people who dwelt upon the upper parts of the mountain not being able to fly fast enough, a great part of the cloud, almost *ten miles* in circumference, detached itself under them, and was seen at a distance rising and falling like the waves of the sea, emitting globes of fire so luminous, that the *night* became as clear as *day*.

18. The effects of it were astonishing: every thing was destroyed for *twenty miles* around; the houses were demolished; plantations were buried in the earth; and two thousand one hundred and forty people lost their lives, besides one thousand five hundred head of cattle, and a vast number of horses, goats, &c.

19. Another instance of a very destructive cloud, the electric qualities of which cannot be doubted, is related by *Mr. Brydine* in his "Tour through MALTA." It appeared on the 29th of October, 1757.

20. About three quarters of an hour after midnight, there was seen to the south-west of the city of *Melita* a great black cloud, which, as it approached, changed its colour, till at last it became like a flame of fire mixed with black smoke.

21. A dreadful noise was neard on its approach, which alarmed the whole city. It passed over the port, and came first on an English ship, which in an instant was torn in pieces, and nothing left but the hulk; part of the masts, sails, and cordage were carried to a considerable distance along with the cloud.

22. The small boats that fell in its way were all broken in pieces and sunk. The noise increased and became more frightful. A sentinel, terrified at its approach, ran into his box; but both he and it were lifted up and carried into the sea, where he perished.

23. It then traversed a considerable part of the city, and laid in ruins almost every thing

that stood in its way. Several houses were levelled with the ground, and it did not leave one steeple in its passage.

24. The bells of some of them, together with the spires, were carried to a considerable distance; and the roofs of the churches were demolished and beaten down, &c.

25. It went off at the north-east point of the city, and, after demolishing the light-house, it is said to have mounted up into the air with a frightful noise, and passed over the sea to Sicily, where it tore up some trees, and did other damage, but nothing considerable, as its fury had been mostly spent at Malta.

26. The number of killed and wounded amounted to nearly two hundred, and the loss of shipping, &c. was very considerable.

27. A remarkable instance of the effect of lightning occurred to DR. FRANKLIN, during his residence in Philadelphia.

28. He was awoke one night by a loud cracking noise on his staircase, as if some person had been lashing the wainscoting with a large horsewhip.

29. He thought it was so, and got up in a fit of anger to chide the idle fool. On looking out

at the chamber door, he saw that the disturbance proceeded from electric explosions, caused by interruptions of his conducting rods.*

30. He saw the electricity pass, sometimes in bright sparks, producing those loud strokes, and sometimes in a long-continued stream of dense white dazzling light, as large as his finger, illuminating the staircase like sunshine, and making a loud noise like a cutler's wheel.

QUESTIONS FOR EXAMINATION.

1. What is a cloud?
2. Of what do clouds consist?
3. Which are the greatest and most considerable of all the meteors?
4. By what are clouds, rain, hail, and snow caused?
5. How long do these particles continue to ascend?
6. What will happen to them when arrived at this region?
7. What happen to some of those vapours that ascend to great heights?
8. What become of the clouds when blown about by wind?
9. From what are mists formed?
10. From what is hail caused?
11. Why is hail so frequent in summer?
12. What is nitre? and what, one of its properties?

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* To preserve men, beasts, and buildings, from the dreadful effects of thunder storms, DR. FRANKLIN constructed the *conductor*, or *thunder rod*, which has since been generally used, and with great success.

13. From what is thunder produced?
14. Of what fluid do all clouds contain a considerable portion?
15, 16, 17. Relate the most extraordinary instance of this kind.
18. What were the effects of it?
19—25. Relate another instance of such a destructive cloud.
26. What was the loss effected by this cloud?
27—30. Relate a remarkable instance of the effect of lightning that occurred to Dr. Franklin.

CHAPTER XXIX.

OF HAIL.

1. HAIL is a meteor generally defined *frozen rain*, but differing from it, in that the *hailstones* are not formed of single pieces of ice, but of several particles congealed together.

2. HAILSTONES are of various shapes; some *round*, some *angular*, and others *thin* and flat.

3. *Natural historians* record various instances of surprising showers of hail, in which the hailstones were of extraordinary magnitude.

4. MEZERAI, in speaking of the war of Louis the Twelfth, in Italy, in 1510, relates, that there was for some time a horrible darkness, deeper than that of night; after which the clouds broke

into *thunder* and *lightning*, and there fell a shower of hailstones, or rather, as he calls them, *pebble-stones*, which destroyed all the fish, birds and beasts of the country.

5. "It was attended with a strong smell of *sulphur*; and the stones were of a bluish colour, some of them weighing one hundred pounds."*

6. At Lisle, in FLANDERS, in 1686, hailstones fell of a very large size, some of which contained in the middle a dark brown matter, which, when thrown on the fire, gave a very loud report.

7. DR. HALLEY and others relate, that in *Cheshire*, *Lancashire*, &c., April 29, 1697, a thick black cloud arose, which disposed the vapours to congeal in such a manner, that for about the breadth of two miles, which was the limit of the cloud, in its progress for sixty miles it did great damage.†

8. It not only killed all the fowls, and other small animals that happened to be within its reach; but split trees, beat down horses and men, and even ploughed up the earth.

9. The very hailstones buried themselves under ground an inch, or an inch and a half deep.

* Hist. de France, tom. ii. p. 339.

† Phil. Trans. p. 203.

10. Many of these hailstones weighed upwards of four pounds, and exceeded five inches in circumference.

11. They were of various figures; some round, others half round, and for the most part smooth, and very transparent.

12. In HERTFORDSHIRE, May 4, 1697, after a severe storm of thunder and lightning, a shower of hail succeeded, which far exceeded the former.

13. Some persons were killed by it, and their bodies were beaten black and blue; vast oaks were split, and fields of rye cut down as with a scythe.

14. The stones measured from ten to fourteen inches round. Their figures were various, some *oval*, others *flat*, &c.*

QUESTIONS FOR EXAMINATION.

1. What is hail?
2. What are the shapes of hailstones?
3. What do natural historians record?
4, 5. What storm does Mezerai relate happened in Italy?
6. What sort of hailstones fell at Lisle, in Flanders, in 1686?
7, 8, 9, What storm do Dr. Halley and others relate, which happened in Lancashire in 1697?

* Phil. Trans. p. 229.

10. What was the weight, and what the size of these hail-stones?

11. What were their figures?

12, 13. What destructive hail-storm happened in Hertfordshire in 1697?

14. What were the measurement and figures of these stones

CHAPTER XXX.

THUNDER AND LIGHTNING.

1. THUNDER is that noise which is caused by the sudden collision and consequent explosion of electrical clouds, which are therefore called *thunder-clouds.*

2. The bright and vivid flash emitted by this explosion is called LIGHTNING.

3. It moves with great violence, and with a very rapid velocity through the air, according to any determination;

4. Upwards from the EARTH, horizontally, obliquely, downward, in a right line, or in several lines joined at various angles; and it commonly ends with a loud rattling noise.

5. In England, although thunder may happen at any time of the year, yet JULY and AUGUST

are the months in which it may always be expected.

6. Its duration is of very uncertain continuance; sometimes only a few peals will be heard at any particular place during the whole season; at other times the storm will return at an interval of three or four days, for *five* or *six* weeks together, or longer.

7. That RATTLING in the *noise* of *thunder*, which makes it seem as if it passed through arches, or was variously broken, is probably owing to the sound being created among the clouds hanging over one another, and the agitated air passing irregularly between them.

8. The *explosion*, if high in the air and remote from us, will do no mischief; but when near, it may prove very destructive, as it often destroys houses, animals, trees, &c.

9. The proximity of THUNDER may always be estimated from the time between the *flash* of *lightning* and the *thunder*.

10. If the interval be short, the thunder is very near; but if the time between the *lightning* and the *report* be considerable, the thunder is at several miles distance.

11. LIGHTNING always strikes the most ad-

vanced and prominent objects; such as *hills, towers, steeples, trees,* &c.

12. It dissolves *metals,* melts *wire,* and tears to pieces bodies which contain moisture.

13. When a person is killed by *lightning,* his shoes are generally burst to pieces.

14. When it falls on a wet surface, it spreads along it.

15. Previous to a *thunder-storm,* the WIND, for the most part, is calm and gentle. A low dense cloud rises in a part that was previously clear; this increases fast in size; but the increase is only upwards, and in an arched form, like *bags of cotton.*

16. The heavens quickly begin to darken; the whole mass sinks down, and the *lightning* and *thunder* then begin to roll and dart from cloud to cloud.

17. The phenomena of lightning are always surprising, and sometimes very terrible; but the most formidable and destructive shape which lightning is ever known to assume, is that of BALLS OF FIRE.

18. The motion of these is very often easily perceptible; and wherever they fall, much mischief is generally occasioned by their bursting,

which they always do with a sudden explosion like that of fire-arms.

19. The next to this, in its destructive effects, is the zigzag kind.

20. The colour of the lightning also indicates the power to do mischief; the palest and brightest flashes being the most destructive; such as are red, or of a darker colour, commonly do much less damage.

21. There is also a kind of lightning unattended by thunder.

22. This is of the sheet kind, which happens very frequently in windy weather, when the sky is clear; and also when the sky is cloudy, immediately before a fall of rain or snow.

23. LIGHTNING possesses a surprising property peculiar to itself, particularly the zig-zag kind.

24. For instance, if two persons are standing in a room looking different ways, and a loud clap of thunder accompanied by zig-zag lightning happens, they will not only both distinctly see the flash, but the very form of the lightning itself, and every angle it makes in its course.

25. Again, if a person happened at that time to be looking in a book, or other object which

he held in his hand, he would distinctly see the form of the lightning between him and the object at which he looked.

26. This property seems peculiar to lightning, and to belong to no other kind of fire whatever.

27. The following singular effect of lightning upon a piebald bullock, is recorded in the 66th vol. of the *Philosophical Transactions*.

28. " In the evening of the 28th of August, 1774, there was an appearance of a thunder-storm, but we heard no report.

29. " A gentleman who was riding near the marshes not far from this town (*Lewes, in Sussex*), about nine o'clock in the evening, saw two strong flashes of lightning running along the ground of the marsh.

30. " On Monday morning, when the servants of Mr. Roger, a farmer at Swanborough, went into the marsh to fetch the oxen to their work, they found one of them much burnt, and scarcely able to walk.

31. " This animal was struck by lightning in a very extraordinary manner. He was of a *white* and *red* colour; the white running in various directions along both sides.

32. " The lightning, with which he must have

been undoubtedly struck, fell upon the rump, which was white, and distributed itself along the sides in such a manner, as to take off all the white marks as low as the bottom of the ribs, but so as to leave a list of white hair, about half an inch broad, all round where it joined to the red, and not a single hair of red appeared to be touched.

33. "The animal for a time was greatly reduced in flesh, but he ultimately recovered."

EXPLANATORY REMARKS.

1. COLLISION is the state of being struck together.

ELECTRICAL means attractive without magnetism; produced by an electric body, which possesses the property, whereby, after being rubbed, excited, or heated in some particular degree, it acquires the power of attracting and repelling other remote bodies; and frequently of emitting sparks and streams of light. An easy experiment can be made upon this property by rubbing the end of a stick of sealing wax briskly upon woollen cloth, or any other soft substance, till it becomes heated, when, upon a very small piece of tissue-paper being placed at a moderate distance from it, it will attract the paper, and raise it from the table.

2. EMITTED means driven outwards, darted, sent forth, &c.

4. HORIZONTALLY signifies on a level, or in a line equally distant in all its parts from the ground, supposing the ground to be level.

9. PROXIMITY is the state of being near, nearness.

QUESTIONS FOR EXAMINATION.

1. What is thunder?
2. What is lightning?
3, 4. How does lightning move?
5. When does thunder happen in England?
6. How long is its duration?
7. To what is that *rattling* in the noise of thunder owing?
8. Is the explosion dangerous?
9. How may the nearness of thunder be estimated?
10. When is it near? When, at a distance?
11. What objects does lightning always strike?
12. What does it dissolve? and what, tear in pieces?
13. What happens to a person's shoes when he is killed by lightning?
14. What does the lightning when it falls on a wet surface?
15, 16. What occurs previous to a thunder-storm?
17. What is the most destructive shape in which lightning appears?
18. What is the motion of these *balls of fire*?
19. What kind of lightning is the next in its destructive effects?
20. What does the colour of the lightning also indicate?
21. What other kind of lightning is there?
22. What is this kind? Where does it happen?
23. What peculiar property does lightning possess?
24, 25. Relate an instance or two.
26. To what does this property seem only to belong?
27—33. Relate a singular effect of lightning upon a piebald bullock, as recorded in the 66th vol. of the *Philosophical Transactions*.